Observational Studies of the Learning Behaviour of Distance Education Students using an Asynchronous, Remote, Recording and Replay Tool

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Observational Studies of the Learning Behaviour of Distance Education Students using an Asynchronous, Remote, Recording and Replay Tool.

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Abstract

This thesis gives details of a series of studies that were designed to investigate how distance education students use courseware in their learning and how time, comfort and learning styles, should be taken into account when designing distance education courses. The online behaviour of groups of distance education students, who volunteered to take part, were observed using an asynchronous, remote recording and replay tool (AESOP) as they completed online practical exercises as part of the Open University course *M206 Computing: An Object Oriented Approach.* Web based questionnaires were used to determine data not obtainable from the recording software, including students' levels of comfort with computing tasks and learning styles as measured by two well known questionnaires and another developed for the study.

The profile of the times at which students study suggests the times at which they study are constrained by their personal circumstances. Time of day was not found to be a factor that affected academic performance or online behaviour. Students' self expressed levels of comfort with computing tasks were found to be significantly related to academic performance. Significant relationships were also noted between students' levels of preferences for the *Activist* and *Dependent* learning styles and academic performance. The *Theorist*, *Collaborative* and *Visual* styles were also found to be significantly related to the time students took to complete online practical work. A series of fine grained analyses looking at students workspace arrangement, use of the notes page and sequence in which they used the course material, all raise further issues pertinent to the research and improvement in computer based instructional materials and distance education.

Publications

Thomas, P. G. and Logan, K. (2001), 'Observational studies of student errors in a distance learning environment using a remote recording and replay tool', in *Proceedings of 6th Annual Conference on Innovation and Technology in Computer Science Education (ITiCSE)*, 25-27 June 2001, Canterbury, UK, Association of Computing Machinery (ACM).

Logan, K. and Thomas, P. (2001a), 'Learning Styles in Distance Education Students', in *Proceedings of British Psychological Society Centenary Conference "Psychology and the Internet" [Abstracts Only]*, 7-9 November 2001, QinetiQ, Farnborough, UK, British Psychological Society.

Logan, K. and Thomas, P. (2001b), 'Observations of student working practices in an online distance education learning environment in relation to time', in *Proceedings of 13th Annual Workshop of Psychology of Programming Interest Group (PPIG)*, 17-20 April 2001, Bournemouth, UK, pp. 29-38, Print Unit, Sheffield-Hallam University, Sheffield, UK.

Logan, K. and Thomas, P. (2002a), 'Learning Styles in Distance Education Students Learning to Program', in *Proceedings of 14th Annual Workshop of Psychology of Programming Interest Group (PPIG)*, pp. 29-44, Printing Services, Brunel University, Uxbridge, London, UK.

Logan, K. and Thomas, P. (2002b), 'Learning Style Preferences of Computing Students in Distance Education', *Journal of Intelligent Systems*, **12**(2), 93-112.

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Chapter 1.

Introduction

"One of the enduring difficulties about technology and education, is that a lot of people think about the technology first and the education later."

Dr Martha Stone Wiske, cited by Schacter (1999)

The Research

The field of education has always taken advantage of technologies to enhance learning as they have become available and cost-effective enough to be used. One only has to look back through history to see examples of this, such as chalk and slate boards, paper and pencil, the printed book, magnetic tape to record and present audio and/or audio-visual material to name some of the major technological changes.

Since their inception, computers have increasingly been used to support teaching and learning. As the cost of hardware has come down the number of students able to access computers in educational establishments and for private use has increased. However, for students in distance education, access is still not ubiquitous. A survey carried out in 2002 in the United States found that households with higher education levels were more likely to own machines and have internet access than those with lower education (NTIA, cited by Ginsburg, 2004), while a report compiled for the Open University in 2000 found that 11% of students had no access to a computer either at home or at the place they worked (Kirkwood and Rae, 2000).

However, the increased availability of computers has lead educators to take advantage of this technology and as a result pedagogical software, or courseware, has proliferated both as support to the main course materials and, more recently, as the primary means of teaching often referred to as e-learning. In a distance education environment, courseware is used by students working on their own, often remote from the teachers who developed it. There is a need, therefore, to ensure that the courseware is effective particularly since it is often expensive to produce.

This thesis therefore sets out to investigate the extent to which specific aspects of the student learning process can be taken into account by both students and course designers alike to improve the learning experience, attainment and accessibility of the course, to maximise the achievement of a course's goals. The approach adopted examines the interaction between students' learning styles, their online behaviours and their course outcomes, to identify factors that should be taken into account when designing distance education courses and the courseware that accompanies them.

The Background

Over the years, courseware has taken on different forms and different names have been used to refer to it. Alessi and Trollop (1991) for example note the following terms in use at the beginning of the 1990's: computer-assisted learning (CAL), computer-based instruction (CBI), computer-assisted instruction (CAI), computer-based education (CBE) and instructional application of computers (IAC), to which we must now add e-learning. In this thesis the term computer-based instruction (CBI) is used.

One of the main attractions of CBI is the ability to teach through multimedia material. Multimedia is defined as the presentation of two or more mediums together at the same time (Mayer, 1997) and there has been extensive research into the effectiveness of multimedia in teaching as well as its methodological application (Mayer and Sims, 1994; Mousavi et al., 1995; Mayer, 1997; Alty, 2002; Moreno, 2002; Antonietti and Giorgetti, 2003). Research into the methodological application of multimedia has identified two main conclusions:

1. That some types of information can be remembered both verbally and visually, leading to better recall. This follows from Paivio's *Dual Coding Theory* (Paivio, 1971b) which suggests that there are two cognitive sub-systems, such that highly 'imageable' words can set up both verbal and visual codes and this dual coding leads to better recall (Baddeley, 1990, p. 106).

2. Multimedia information that is presented in an integrated format reduces the load on working memory. Sweller's *Cognitive Load Theory* (Sweller, 1988; 1989; 1993; 1994) suggests that many common instructional procedures are inadequate because they require learners to engage in unnecessary cognitive activities that impose a heavy load on working memory (Baddeley, 1987; 1990; 1992). Mousavi, et al. (1995) in their study looking at presenting audio and visual material concurrently, argue that the effect of the *Cognitive Load Theory* is reduced if information is presented in a format that reduces the load on working memory. That is, multiple sources of information can be integrated better if they are both in working memory at the same time. Presenting multiple sources of information sequentially reduces integration of the material as earlier material has to be retained in working memory. This is supported by Mayer's work (Mayer and Sims, 1994; Mayer, 1997) which found that there was consistent evidence that students who were presented with co-ordinated material generated a significantly higher number of creative solutions in problem-solving transfer tests and the effect was strongest in those with low prior knowledge and high spatial abilities.

Both of these ideas are significant to education because they suggest that wherever possible materials should be presented both visually and verbally. However the way multimedia information is presented both in combination (diagram, text, audio, video, audio-visual) and sequence (concurrently or sequentially) can significantly alter its effectiveness (Mayer and Sims, 1994; Mousavi et al., 1995; Mayer, 1997).

At this stage, a distinction needs to be drawn between multimedia presentations that are generally inappropriate to the population as a whole, and presentations that are unsuitable for specific groups of individuals. Evidence that some multimedia presentations can be detrimental to specific groups of students is given in a study by Ross and Schulz (1999). To determine learning style preference, Ross and Schulz used the *Gregorc Style Delineator*™, a self-scoring inventory that determines individual cognitive preferences on two processing dimensions, those of ordering (sequential or random) and perception (abstractness or concreteness). Gregorc combined these dimensions into four different possible styles: Concrete Sequential, Concrete Random, Abstract Sequential and Abstract Random. In that study, students' preferences on the style delineator were then compared with their interactions with a multimedia CBI program designed to instruct and test cardio-pulmonary resuscitation theory. Ross and Schulz found that Abstract Random learners - learners who could comprehend what was not visible to the senses, and therefore were not reliant on the physical senses, as well as storing information in a non-linear and multidimensional way - spent less time on average using the CBI program, did not use the video content as much, and recorded fewer events than those with the other learning styles. The mean post-test score of Abstract Random users was also worse than the pre-test score, while the other groups showed significant improvements.

Distance education courses that use CBI materials for their courseware, often take advantage of the multimedia capabilities of students' computers. However, Kulik (1994) in a review of meta-analytic studies, found that apart from all the studies finding positive effects, CBI had the following additional benefits.

1. Students usually learnt more in classes in which they received CBI. The magnitude of the benefit from the different CBI materials varied, but was always positive.

2. Students took less time to learn with CBI. The average reduction in instructional time was noted to be 34% over 17 studies of college education and 24% over 15 studies of adult education.

3. Students enjoyed/liked classes more where CBI was offered.

4. Students developed a more positive attitude towards computers when CBI material was used.

The advantages of CBI are further supported by Kulik's own meta-analysis findings (Kulik and Kulik, 1991; Kulik, 1994) and other reviews of CBI research (Schacter, 1999). Schlechter (1991), cited by Ross and Schulz (1999), argues that effective CBI is able to compensate for a teacher's inability to meet the needs of all learners.

However, Kulik (1994) noted that CBI did not have an effect in every area, such as students' attitude towards their subjects, and that the magnitude of the benefit gained through the use of CBI programs differed both between different programs and different groups. Kulik concluded that while CBI programs usually have positive effects on student learning, the results are not the same for every CBI program and that,

> *"Computer-based instruction is a loose category of innovations. It covers some practices that usually work and other programs that have little to offer."*

CBI therefore is not necessarily effective for all learners and may even be detrimental for some, as Ross and Schulz (1999) found. The question then is 'what factors do we need to consider when designing or creating CBI programs to improve their effectiveness?'

Some of the other factors that researchers have been looking at and being considered in this research are:

- **learning styles** (Dunn and Dunn, 1978; Griggs, 1991b; Grasha, 1996a; Wilson, 1996; Montgomery and Grout, 1998; Valenta et al., 2001),
- **time** (Dunn and Dunn, 1978; Folkard and Monk, 1978; Bååth, 1982) and
- **comfort/self-confidence with computing related tasks** (Casey et al., 2001; Grandjean et al., 2002; Zorkina and Nalbone, 2003).

Learning styles

It has been noted that the effectiveness of pedagogical material can be influenced by the way teachers and course designers choose to deliver the material, and that teachers and course designers often do so in way that is consistent with their own learning style preferences. (Griggs, 1991a; Renniger et al., 1992; Wilson, 1996; Montgomery and Grout, 1998; Lang et al., 1999; Goold and Rimmer, 2000). Research has also shown that individuals can learn more effectively if the pedagogical material is matched to their specific learning style (Dunn and Dunn, 1978; Grasha, 1996b; Montgomery and Grout, 1998).

In the traditional classroom environment, if a student has difficulty understanding the information because of the way it is presented, a teacher has the opportunity to adapt and present the information in different ways. However, in distance education, students do not always have access to a tutor and those students that do are limited by the restrictions implicit to distance education. A way of compensating for the lack of contact with a personal tutor in distance learning has been to use multimedia CBI material. However, as already noted, some individuals find types of multimedia presentation detrimental rather than beneficial. This has led researchers to explore these issues further and examine the potential of customising educational software to the individual (Greenberg and Witten, 1985; Liu and Reed, 1994; McWilliams, 2001; Osipova et al., 2001).

There are a large number of learning styles to be considered and is it impractical to include them all in the same research. A fuller discussion of some the learning and cognitive styles and the ones selected for use in this research is covered in Chapter 5.

Time

Time is relevant to distance education because students often choose to enrol on distance courses for the reason that it allows them to study materials in their own time and therefore at times they prefer, or find they are able to (Bååth, 1982). From this it can be assumed that distance education students tend to work during the hours that are suitable to them. However, the effect of time on learning has a historical precedence and a number of studies have found time to be an important consideration with regard to learning.

Gates (1916, cited by Folkard and Monk, 1978) when investigating the effect of time of day on memory (because of its implication for scheduling of classes), found that immediate recall of information is better in the morning while motor tasks are performed better in the afternoon. In contrast, Folkard and Monk (1978) noted that although recall from short term memory was better in the morning, recall from long term memory was not affected by the time day. However, information was encoded better and more easily recalled from long term memory if it was learnt later in the day, effectively following the body's levels of arousal. Additional work by Dunn and Dunn (1978), both in their own studies and in a review of other work on cognitive and learning styles found that students had a recognised preference for the time of day they studied. They also found a number of students had a preference for alternative teaching styles at different times or on different days.

Distance education students as a group have a diversity of lifestyles and therefore would be expected to exhibit a diversity of times of the day or even day of the week that they choose to study. However, as individuals, students are restricted by the limitations placed on them by their particular lifestyle. As memory can be shown to be affected by the time of day, it is possible that the time of day distance education students choose to study can affect their academic performance.

Comfort with computing tasks.

In addition to the factors of learning style and time, there are a number of studies which show that individuals with lower self-confidence, and who therefore are less comfortable with those tasks they are not confident in, perform more poorly that those with higher self-confidence (Casey et al., 2001; Grandjean et al., 2002; Zorkina and Nalbone, 2003). Other research has shown that females often express less confidence than males with computing related tasks (Shashaani, 1994; Busch, 1995; Corston and Colman, 1996; Comber et al., 1997; Durndell et al., 2000).

In the light of these observations, it is possible that distance education students who express lower levels of confidence with carrying out computing related tasks will not use CBI as effectively as those who are more confident, and therefore comfort is another factor that needs to be considered when designing courseware.

Intelligent Tutoring Systems

A research focus for computing scientists has for a long time been artificial intelligence while for instructional scientists the computer has increasingly been perceived as a tool for enhancing learning. It is therefore not surprising that the two research fields have willingly combined traditionally distinct areas to develop adaptive learning environments (Murphy, 1997). Of these adaptive learning environments Intelligent Tutoring Systems (ITSs) are perhaps the most well known.

ITSs are CBI systems that have embedded models of *what* and *how* to teach and are able to make inferences about individual users in order to dynamically adapt the content or style of instruction to that user (Singley et al., 1991; Murray, 1999; Virvou and Tsiriga, 2000). However, because students learn more effectively if pedagogical material is matched to their specific learning requirements (Dunn and Dunn, 1978; Grasha, 1996b; Montgomery and Grout, 1998), the ability of ITSs to dynamically adapt and match material to a student's preferences makes them a desirable method of delivery.

There are a number of ITS classes, methods by which ITSs work, and a concise introduction to these is given by Murray (1999), however a class of ITS of particular relevance to this research are the *Expert Systems/Cognitive Tutors*. These systems build a model from observations of student's behaviour and knowledge, which can be compared against an 'expert' model of expected behaviour. Expert systems are of interest to course designers and students because in addition to catering to individual preferences and therefore being an effective method for pedagogical delivery, they also have the potential to (and usually do) provide feedback to the student when the student's behaviour diverges from the expert model (Murray, 1999). When applied to learning styles, in addition to adapting material to suit individual learning style preferences, this approach would be a way of developing students' awareness of their own learning style preferences and its implications.

The identification of expected models of behaviour is one of the key steps to authoring ITSs. One of the intentions of the research described in this thesis is to explore the behaviours of students working in an online environment and note what relationships, if any, exist between these behaviours and factors such as learning styles. However, as Murray (1999) also points out "Authoring an expert system is a particularly difficult and time-intensive task,...", so it would be useful for designers of courses and CBI material to know how much benefit there is in adapting pedagogical material to the factors of time, comfort and learning styles, and this is a central theme of this thesis. The effects of these factors on academic performance are investigated in this study.

Objectives of the Thesis

The intention of this thesis is to investigate relationships between the factors of time, comfort with computing tasks, and selected learning styles with the behaviour of distance education students' use of CBI material and whether any of these relationships need to be taken into consideration when designing distance education courses and the CBI material that accompanies them. A series of investigations are used to study these areas of interest by addressing the following questions:

1. Do distance education students show a preference for the time of day or day of the week that they work?

2. Does the degree of comfort with computing tasks that a student expresses at the start of a course relate to their use of CBI material?

3. Do distance education students have a greater preference for specific learning styles over the general population?

4. Is there a relationship between individuals' preferences for selected learning styles and their use of CBI material?

5. Do any of the factors of learning style, time or comfort relate to students' ability to learn as measured by their academic performance or time to complete tasks?

6. If any factors are found to affect the use of CBI and noted to significantly affect a student's performance, is it possible to identify these factors/styles automatically and therefore enable software to be automatically adaptive to meet individuals' needs?

The Methodology

Almstrum, et al. (1996) comment,

> *"Because the scientific method we are taught in school tells us to derive hypotheses from theory and to design controlled experiments to prove or disprove those hypotheses, some people believe that the hypothetico-deductive method and the definitive experiment are the only rigorous evaluation tools."*

Most of the studies looking at CBI have used laboratory based experimental methodologies to study the effects of the different attributes being investigated. However, laboratory based experiments are difficult to reproduce if not impossible to perform in a more natural setting (Saba, 2000) and make it difficult to control for factors that possibly could influence the outcome. This is particularly relevant to research in distance education, where students learn in their own time at home and/or at work.

The use of CBI materials in distance education courses is becoming more common (Schwittmann, 1982; Charp, 1999; Valenta et al., 2001; Wijekumar, 2001). As it is the behaviour of distance education students using CBI materials in their own time and own environments that we wish to capture, a method of observing their behaviour was needed without the possible bias of the experimenter being present and disrupting their natural working conditions (Good and Watts, 1989). In addition, we did not for ethical reasons want to unduly disturb or influence any students' studies.

A method of capturing students' use of online material was therefore needed. One consideration was the accuracy with which students' input and output can be recorded. Another consideration was whether a researcher needed to be present or not. An overview of some of the ways this issue has been approached is also mentioned by Smith, et al. (1991; 1993) and includes,

Think aloud protocols: These are taken from the written transcript of subjects' verbalisations of their own thinking as they work on a task and are a rich source of information. Disadvantages include the need to prompt subjects to verbalise, the difficulty of expressing complex technical procedures, and the possibility of disrupting/modifying the actual behaviour.

Video tape (Card et al., 1983; Singley et al., 1991): Video cameras are used to record interactions with the computer. Disadvantages are limited functionality, requiring extensive analysis, and coding of the videotaped data into analysable data.

Key logging (Card et al., 1983): This records every keystroke input that the subject makes and allows users' interactions with the computer to be recorded passively without the need for the experimenter to be present. Disadvantages are,

- production of large amounts of very fine grained data and decoding this is a formidable task,
- an application is needed which can duplicate the computer's structure and applications in order to interpret the users' key logged commands,
- key logging does not record mouse movements, so many interactions particularly those in graphical user interfaces are not recorded.

Currently the most common approaches being used are:

Eye Tracking (Vertegaal, 1999; Vertegaal and Ding, 2002; Shell et al., 2003; Tzanidou, 2003; Vertegaal, 2003): Hardware is used to monitor users' eye movements and records the location and duration of their gaze. Used in combination with software, the specific points/items being viewed on visual display units and duration of the gaze can be determined.

Monitoring computer mediated communication (CMC), (Wilson and Whitelock, 1997; Wilson and Whitelock, 1998; Berglund, 2001; Hause and Woodroffe, 2001): Used mainly in research into co-operative and/or collaborative work between individuals or groups of individuals. A disadvantage is that it is time consuming as it relies on coding the emails and other textual/graphical communications between individuals.

There is another approach that has been used in one way or another in the user modelling community, which can be described as *event protocol analysis* ('The GRUMPS Project,'; Bates, 1988; Smith et al., 1991; Smith et al., 1993; Liu and Reed, 1994; Bates, 1995; Kivi et al., 1998; Thomas et al., 1998a; Ross and Schulz, 1999; Hilbert and Redmiles, 2000; Thomas et al., 2000; Logan and Thomas, 2001b; 2001a;

McWilliams, 2001; Logan and Thomas, 2002a; Evans et al., 2003). These are typically either programs embedded in the CBI material or external software tools which record users interactions with the computer via events that take place at a higher level of abstraction than keystrokes. This method has a number of advantages,

- it captures data frequently missed by keystroke protocols, such as mouse movements (Smith et al., 1991),
- it is passive and unobtrusive and therefore does not cause cognitive interference (Smith et al., 1991; Thomas et al., 1998a),
- it records a much smaller number of events and consequently a much smaller volume of data (Smith et al., 1991; Thomas et al., 1998a).

Of interest is the work of Bates (Bates, 1988; Bates, 1995) who uses Event Based Behavioural Abstraction (EBBA), a high level debugging approach comparing actual behaviour to expected models of behaviour. EBBA uses a fairly sophisticated set of tools to build up models of behaviour from more primitive ones using techniques such as filtering to ignore irrelevant behaviours and clustering which abstracts higher level behaviours from aggregates of more primitive ones.

Smith et al. (1991) use the term 'protocol analysis' and for the purposes of the work in this thesis an adapted version of this term *Event Protocol Analysis* (EPA) is used here to describe any process that records users' interactions with the computer at the level of an event or activity rather than as individual keystrokes.

As the group we wished to study were distance education students, working in their own time and own environments, EPA was selected as the preferred method for the specific advantages of being unobtrusive and able to record users interactions remotely and asynchronously to the researchers, and at a level of detail that allowed graphical elements to be monitored.

To enable this, An Electronic Student Observatory Project (AESOP) was devised to monitor distance education students' online behaviour. AESOP is described in greater detail in the following chapter (Chapter 2).

Thesis Justification

Many of the previous studies have been laboratory based and therefore unintentionally controlling for factors that could influence the outcome. As AESOP records distance education students' natural behaviour, the results of the studies being carried out in this thesis will be based on more realistic data.

Until recently there has also been very little research into how individuals use CBI material using EPA and this is an area of research that needs further study to explore not just its advantages but also discover its limitations.

Thesis Structure

The remainder of the thesis is organised as follows:

Chapter 2 Gives an outline of the M206 distance education course from which participants were recruited, describes in detail the tool used to record students behaviour, AESOP, and gives an outline of the LearningBooks examined within the study.

Chapter 3 Describes a study carried out in 2000 and reports on observations of when distance education students work, their behavioural patterns with regard to time and any relationships these have with measures of academic performance.

Chapter 4 Re-examines the data from the 2000 study, and reports on the level of comfort expressed by students at the start and end of the course for carrying out computing related tasks and explores the relationship between students' level of comfort, online behaviour and academic performance.

Chapter 5 Gives an overview of the current state of knowledge in cognitive and learning styles, as well as describing in detail the Honey and Mumford Learning Styles Questionnaire (Honey and Mumford, 1986; 1995), Grasha-Riechmann Student Learning Styles Scales (Riechmann and Grasha, 1974; Grasha, 1996a) and Antonietti and Giorgetti's Questionnaire of Visual Verbal Styles (Antonietti and Giorgetti, 1993), selected for use in the research.

Chapter 6 Describes a study carried out to collate normative data for distance education students on the Honey and Mumford Learning Styles Questionnaire and the Grasha-Riechmann Student Learning Styles Scales.

Chapter 7 Looks at the normative data for distance education students in greater detail to investigate an earlier observation of differences between the genders as well between arts and science students.

Chapter 8 Describes the normative data and validity studies carried out to evaluate the English version of Antonietti and Giorgetti's Questionnaire of Visual Verbal Styles.

Chapter 9 Details the main study carried out in 2001, investigating the relationship between the learning style preferences of distance education students, their use of CBI material, and influences these have on measures of academic performance.

Chapter 10 Examines the data obtained in the 2001 study looking at the relationships between the time that students spent reading in comparison to the time spent actively working on the material, and also examines whether there are any relationships between these and preference for the visual or verbal learning styles.

Chapter 11 Re-examines the 2001 data in a series of fine-grained studies looking at three different behaviours: Students arrangement of windows in their online working space, students' use of the notes page and the sequence in which students approach the course materials. Individuals' behaviour and their relationship with individual characteristics and performance are also explored.

Chapter 12 Compares students' pre- and post-study learning style preferences from their responses to the questionnaires in the 2001 study.

Chapter 13 Discusses the findings of the research further and the wider implications of the findings.

Chapter 14 Concludes the work by discussing the limitations of the study, the implications of these and the way forward.

Chapter 15 Explores a number of potential areas of future research, raised by the study.

Chapter 2.

An Electronic Student Observatory Project (AESOP)

Abstract

This chapter describes in detail AESOP (An Electronic Student Observatory Project), a collection of software tools for the remote, asynchronous recording and replaying of students' interactions. The Open University distance education course *M206 Computing: An Object-Oriented Approach*, that students' taking part in the research are studying and being observed using AESOP is also described.

Introduction

AESOP is a collection of software tools specifically designed for the asynchronous, remote recording, replaying and automatic analysis of students' interactions using EPA (Thomas et al., 1998a; 1998b; MacGregor et al., 1999; MacGregor, 1999; Thomas and Paine, 2000b; 2000a; 2000b; Logan and Thomas, 2001b; 2001a; Thomas and Logan, 2001; Logan and Thomas, 2002b; 2002a; Thomas and Paine, 2002). AESOP has been built around the Open University's distance education course *M206 Computing: An Object-Oriented Approach* (*The Open University,* 1998b; The Open University, 1998a) which teaches the Smalltalk object-oriented language.

M206 Computing: An Object-Oriented Approach

The two main themes of M206 are Object Technology and Network Computing. Delivery of the course is primarily through paper-based course materials divided into chapters, and online practical exercises that follow each chapter. A number of accompanying television programs related to the course are also broadcast in co-operation with the British Broadcasting Corporation for students to watch and/or record for viewing at a later time.

Practical work uses a customised LearningWorks environment (Ingalls, 1981; Goldberg et al., 1997), designed by Adele Goldberg to meet the needs of the M206 course (Woodman et al., 1998; Griffiths et al., 1999; Woodman, Griffiths, Macgregor and Holland, 1999; Woodman, Griffiths, Macgregor, Robinson et al., 1999; Woodman, Griffiths, Macgregor, Holland et al., 1999). Students receive the LearningWorks software as a CD-ROM along with their paper-based material at the start of course in January when the Open University academic year starts, and are given instructions on how to install the LearningWorks environment and HTML material contained on the CD-ROM onto the machine they will be using for their practical work. Later in the course students receive a second CD-ROM which they have to install, which contains a fuller version of LearningWorks.

LearningWorks consists of a number of pre-packaged modules called LearningBooks (LBs) with each LB being associated with a chapter of the M206 course, allowing the student to practice the theory covered in that chapter. In addition each LB is divided into a number of sessions which are a series of practicals (typically around 5 - 10) with the recommendation at end of each session that the person returns to the paper based content of the course.

Students throughout the course have access to a tutor, and to an electronic conference, FirstClass™ (*Soft Arc Online,* 2003), which they can use to communicate with other students on the course.

In common with other distance education courses at the Open University, students are assessed at specific points during the course through pieces of assigned work (Tutor

Marked Assignments (TMAs)) that need to be completed by a set time. The marks given for these assignments (Overall Continuous Assessment Score (OCAS)) along with the marks gained in a conventional paper-based examination at the end of the course in September (Overall Examination Score (OES)) are combined to give the student's final grade for the course.

Observation of students' interactions in AESOP is achieved through three applications built around the LearningWorks Smalltalk environment: the 'Recorder', the 'Replayer' and the 'Analyser'.

Recorder

The Recorder consists of two small application files, *obs.st* (172KB) and *course.dfn* (1KB). The file *obs.st* contains a number of additional Smalltalk classes containing the code for the Recorder. The file *course.dfn* replaces a file of the same name in the LearningWorks system and is used to identify the components of the LearningWorks system in the current implementation. During installation of the new application files, the existing *course.dfn* file is renamed as *course.old* to enable students to uninstall the Recorder software with ease should a problem occur in the Recorder. The installation process also creates a sub-folder named 'recordings' in the LearningWorks directory on the user's hard drive into which recordings are saved.

In order to minimise the need for users to interact with it and therefore be unobtrusive as possible to reduce any effects students may have of being watched (Good and Watts, 1989), the recorder was designed to launch automatically and to invisibly start recording whenever a student opens up a Learning Book (LB).

The Recorder is unable to record anything outside the LearningWorks environment, but records to a text file any events occurring within each LB which had been defined by the AESOP team as being of interest. These include:

- *Opening and closing of LBs:* These identify the start and end of sessions.
- *Opening, selection, movement and resizing and closing of windows:* Allowing researchers to view how the student uses and organises their workspace.
- *Scrolling, button clicks, hyperlink selection:* Allowing feedback on students' use of windows with textual content and how instructions have been followed.
- *Text typed by the student / evaluation of expressions:* Expressions are Smalltalk program code entered by the student.

In addition, each individual event is time stamped with the date and time obtained from the operating system. The inability to record anything happening outside the LearningWorks environment meant it was impossible to determine when students stopped or paused in their use of the LBs, whether they were using another software program, or doing something away from the machine they were working on. However the ability to record events happening outside the bounds of the LearningWorks environment also raises issues of privacy and whether students should be able to control what is recorded (Cooper, 1998; Martin Jr et al., 2001; "The Stanford Student Computer and Network Privacy Project", 2002).

A new file of recorded events (appended *.obs*) is created for each LB that is opened, but if the LB is closed and subsequently reopened at a later date or time, the new recorded events are appended to the relevant LB file regardless of whether other LB have been opened in the intervening time.

An example of the text output from the recorder can be seen in Figure 2.1. The output is designed to be easily read by a human evaluator and many lines in Figure 2.1 are clearly related to window manipulation and hyperlink usages (lines beginning with enter, tab and scroll for example). Other lines represent user interaction with the Learning Book as noted in Figure 2.1.

Event indicating a Dialog box was created with the message "select the text you wish to evaluate". Choice/s given are <OK>

User selected the dialogue button labelled <OK>

User asks the system to evaluate the expression given on the previous line

```
□enter:i0/LB-09 Smalltalk Expressions:  Expressions□03/05/2000 13:39:24.000
□select: gribbit in: listModel□03/05/2000 13:39:25.000
□DIALOG:Select the text you wish to evaluate CHOICES:('OK')□03/05/2000
13:40:03.000
□OK□03/05/2000 13:40:03.000
□*gribbit colour□03/05/2000 13:40:11.000
□evaluateIt□03/05/2000 13:40:11.000
□MA: Green□03/05/2000 13:40:11.000
□*gribbit colour: Red□03/05/2000 13:40:56.000
□evaluateIt□03/05/2000 13:40:56.000
□MA: An instance of class Frog (position  1,  colour Red)□03/05/2000
13:40:56.000
□tab:i1 'World'□03/05/2000 13:41:02.000
□MA: An instance of class Frog (position  1,  colour Red)□03/05/2000
13:41:04.000
□tab:i2 'Workspace'□03/05/2000 13:41:04.000
□inspectAnswer□03/05/2000 13:41:12.000
□enter:i1/LB-09 Smalltalk Expressions: Practicals and Notes:
Practicals□03/05/2000 13:41:53.000
□scrollVertically:n324 in:htmlView□03/05/2000 13:42:03.000
□scrollVertically:p0 in:htmlView□03/05/2000 13:42:03.000
□enter:i0/LB-09 Smalltalk Expressions:  Expressions□03/05/2000 13:42:03.000
□*kermit colour: Yellow□03/05/2000 13:42:49.000
□evaluateIt□03/05/2000 13:42:49.000
```

* - indicates text that the user has directly typed in into the workspace

Enters the Practicals page of the 'Practicals and Notes' section of the LearningBook

Date and time stamp for that event

Figure 2.1: Sample of text record made by the Recorder tool. Areas highlighted show notable features.

Because users of AESOP are distance education students who work in their own time using their own machines, no automatic method for retrieving recordings was set up. Recordings were returned by participants as email file attachments and the project was reliant on the participants' good nature in this respect. One of the advantages of a recording being a text file was its small size, which could be made smaller if necessary using commonly available free, file compression software.

Participants were required, and reminded, to reinstall the Recording software after they were sent the second CD-ROM part way through the course, as installation of the fuller version of LearningWorks on the second CD-ROM would replace the *course.dfn* file.

Installation

Students were required to download the recording software, and since most were using relatively slow modems, care was taken to minimise the size of the file to be downloaded.

The recording software was made available as a self-installing package which contained the relevant files required for the Recorder and which created the 'Recordings' sub-folder. The package also contained a small text help file explaining the installation of the Recorder and identifying where to find the recordings. A self-executable file to uninstall the AESOP Recorder if students desired, was also included. The addition of the uninstaller did however increase the size of the installation package and therefore the potential time required to download it.

The remaining AESOP software tools were held on the researchers' own machines and were not required to be downloaded by students.

Replayer

The Replayer was developed to assist in the observation and analysis of users' actions by allowing the text recording created by the Recorder to be transcribed from text back to visible actions on the LearningWorks GUI, as it would be viewed by the user who created it. This includes replaying all significant events as logged by the Recorder as well as carrying out the evaluations of any Smalltalk expressions defined by the user in the workspace. The advantage of replaying text files in this fashion, particularly where students are adding new programming code, is that the LearningWorks system automatically adds any new objects or code created by the student to the system and shows any error messages that result from the student's input. However, this meant that recordings could not be reviewed from an arbitrary point and had to be replayed from the start each time.

The text being transcribed in the recording was presented in a separate, resizable window that could be scrolled through, so that the line of text or command being carried out was by default highlighted and centred in this window (Figure 2.2).

As the original text record has one instruction to each line, the Replayer could carry this out in a 'frame-by-frame' or 'line-by-line' step-wise fashion or continuously at a set pace controlled by a sliding scale (Figure 2.2). The ability to manually edit text files in the Replayer window and add a stop command gives further functionality to the Replayer, allowing files to be replayed at high speed. The primary use of these features was to allow fast forwarding to the point at which the stop command was added and then enable the recording to be replayed at a more convenient speed to view and analyse the user's actions.

It was noted however that when a LearningBook is opened, each section, or window, launches with a pre-determined minimum size. LearningBook windows could be enlarged, but not reduced in size. The minimum window size was also defined in absolute (number of pixels) rather than relative terms (percentage of screen size), which meant that students who were using very low resolution screens (640x480 pixels) would only be able to view one window at a time while those using higher resolutions

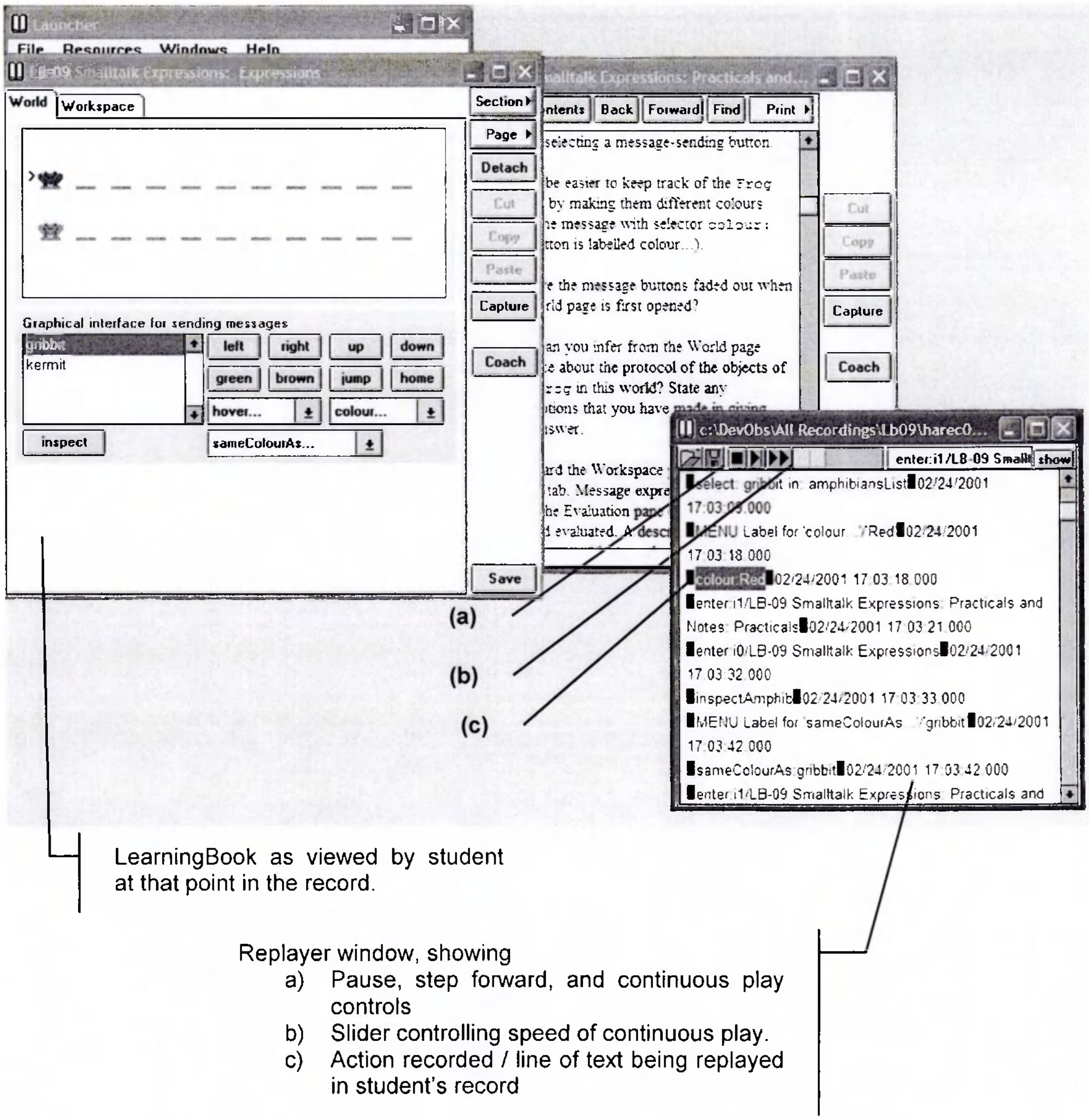


Figure 2.2: Screen capture of the Replayer in use showing LearningBook as the student would have been viewing it at that point in time, the Replayer window and controls.

(800x600 pixels or greater) would be able to position their windows further apart and view both at the same time. This however necessitated the replay of records on screen resolutions equal to or better than the screen resolution used by the student, otherwise the screen placements of the active LearningWorks windows would then be a 'best fit' and give a distorted view of what the user actually saw.

Analyser

Analysis of students' recordings was initially performed by reviewing by eye. However, as each student had the possibility of returning a maximum of 24 learning books and the average time to review a record being well over an hour, it was an impractical proposition to review by eye the number of potential records (3399 students registered for the M206 course in 2000) in the time frame available. Therefore more effective and automatic methods of reviewing the data were sought. This lead to the development of the Analyser consisting of a set of tools that were capable of automatically editing, filtering and analysing the records individually or as a group.

Pilot Study

Prior to the work reported on in this thesis, a small pilot study had been carried out using a small number of students (n=24) (MacGregor et al., 1999). This proved the effectiveness of the tool in recording suitable events, but highlighted some problems with the Replayer and the type of events that were being recorded. This led to changes being made to the Recorder that allowed greater detail to be observed, and some refinements were made to the Replayer. It was this latter version of the Recorder that was used in the first of the studies reported here (2000 presentation of the M206 course).

A result of observations made from the year 2000 presentation was further refinements being made to the types of events being recorded by the Recorder and the development of additional Analyser tools. The third version of the Recorder was then used for the subsequent study using the 2001 presentation.

The Coach

Although the Coach (Thomas et al., 2000) was not used in any of the studies mentioned in this thesis, it is worth briefly mentioning here as it was a direct development from the use of AESOP and the observations of students' recordings in the 2000 presentation as discussed in this thesis. One of the additional observations made was that many students found it difficult to comprehend the error messages generated by LearningWorks when it evaluated an expression they had just typed that had errors in it.

The concept of the Coach was to provide more detailed feedback than was currently available from the LearningWorks environment. However, it was also viewed as an additional teaching tool and therefore would provide additional information, but would stop short of providing a solution to a problem. As such the Coach was designed to be accessible directly from the LearningWorks error message window and also directly from the LearningWorks interface should a student desire it. The help provided by the Coach was also designed to be context sensitive, that is help relevant to the point at which it was accessed, by providing details of the last event recorded, navigational tools to references that concern the problem, as well as a list of common mistakes made by students that might provide clues to the problem. The latter list of common mistakes was refined by enabling the Coach to build a frequency profile of the errors made by a student and adjust the presented order of suggested common mistakes accordingly.

Part of the Coach's specification was that it also required the Recorder to record students' use of the Coach. The relevance of this functionality is reviewed later in the 'Further Discussion and Summary of Findings' (Chapter 13).

The LearningBooks

There are 29 LBs in LearningWorks that deliver a mixture of prescriptive and exploratory activities in two general concurrent delivery patterns; 1) provision of early prescriptive activities that lead into increasingly greater exploratory work and 2) a cyclic approach of revising and building on earlier material. The general layout for LBs is therefore guided and prescriptive delivery early on, with later LBs delivering more exploratory content.

In the research presented in this work, students' recordings of the following LBs were examined:

LB09 - Smalltalk Expressions

This LB introduces the *Workspace* page, a text-based interface, used in all subsequent LBs and replaces the text-based interface previously used on the graphical *World* page. The emphasis of LB09 is on examining and evaluating Smalltalk expressions and additionally in the use of workspace and inspector tools. LB09 is divided into 21 practicals, each of which is prescriptive, asking students to evaluate set code and observe the resultant behaviours.

LB10 - References to Objects

This LB uses the same user interface as LB09 and explores the nature of references, variables and the concept of assignment. The 10 practicals are mainly prescriptive, but later ones require students to revise earlier simple code by using it for example to create new instances of an object.

LB12 - Discussing Software

The practical work in this LB is designed to enable students to explore and criticise new classes from a software developer's perspective. Students are introduced to the new Classes tab added to the user interface, then prescriptively guided through the process of creating three new classes and sending various messages to these. In the final practical (Practical 9), students are asked to make a critical appraisal of the software and post this to the M206 conference.

LB13 - Creating New Behaviours

Practicals in LB13 introduce students to the *Class Browser*, which replaces the Classes tab in the user interface and is used to examine existing methods and create new ones. Students are guided through a series of 10 practicals focussed on creating new behaviours for a class of objects by creating new methods. In the last two practicals, students are asked to create two methods and are given analogous code as a template, which does not require them to explore prior material, although this is possible.

LB14 - New Behaviours: Answers and Arguments

The 15 practicals in LB14 build on students' skills in creating a new behaviour for a class by the writing of appropriate methods that explicitly return a message answer and take arguments. Later in the LB, students are introduced to the Argument and Precedence tools, pages that have been added to the user interface. LB14 is the first LB to ask students to develop their own code to carry out a set function without being guided or given an analogous template from which to work.

LB15 - Subclasses

The content of LB15 discusses how to create new classes, how classes inherit behaviour from their superclass, how this behaviour can be modified, and how initialisation works. Similarly to LB14, students are guided at first, and then asked to initialise objects, create and modify classes to carry out a set function, without being given additional help.

LB20 - Collaborating and Orchestrating Objects

This LearningBook is about collaborating and orchestrating objects, repetition messages, and state-dependent behaviour. All the practicals in LB20 require students to create their own code to solve problems (making Frog objects dance in different sequences).

Examples of these pages can be seen in the screen shots, in Chapter 11, of the *Practicals* page and *Notes* page shown in Figure 11.2, and the *Workspace, World, Class Browser, Arguments* and *Precedence* shown in Figure 11.3.

Chapter 3.

Observations of Distance Education Students Working Practices with Regard to Time

"Behavior consists of patterns in time. Investigations of behavior deal with sequences that, in contrast to bodily characteristics, are not always visible."

Eibl-Eibesfeldt, I. (1975), p 1.

Abstract

This chapter describes an observational study of distance education students' use of computer based instructional material, to determine the effects of time on their behaviour and academic performance. The time of day students worked was not found to affect academic performance. Students were noted to work at any time during the day or night, but more had a preference for studying in the afternoon around lunchtime and the majority of students in the evening started work around 21:00. The amount of time students spent working on the computer based material was also found to differ significantly between individuals.

Introduction

Time has been identified as both an important tool and factor when looking at human behaviour, because it allows us to place a series of events in chronological sequence either in relationship to each other or to other external events or factors. Some studies mentioning time and of relevance here include:

Bååth (1982), in his study he found that students chose to undertake distance education courses because of time constraints and the flexibility with regard to time these types of courses offered. In addition he found that there was considerable variation in the time that students took to complete course material. In one case the variation was as great 529 hours.

In similar work, Jacobsen et al. (2000), looking at computer mediated distance learning also found that students took varying amounts of time to complete their work. However they felt that computer mediated distance learning offered several learning advantages to students that went beyond "anytime, anywhere" access including, learning about networks and computers, interaction and contact with experts and others outside of their immediate community or workplace setting, increased self reliance and development of independent learning approaches.

Work by Greenberg and Witten (1985) looked at the viability of adaptive interfaces and used time as the dependent variable. Their finding, that information was quicker to retrieve via an adaptive interface, supported the use of adaptive user modelling. While Gould et al. (1987; 1987) studied the time users took to read text from a visual display unit compared to paper. They came to the conclusion that although reading from paper can be quicker, the quality of the screen resolution was an important factor such that when the characters on the two media appeared similar, users read just as fast from paper as they did from the visual display.

Card et al (1983) looked at participants interactions with the POET text editor, with the aim of describing how a user decides which method to use for a task, describing the temporal sequence of events that take place and investigating how the adequacy of the description varies as a consequence of the granularity of analysis. In similarity to the AESOP recording tool, users' interactions were recorded by the use time stamped keystrokes supplemented by hand-coded actions taken from either think-aloud or video taped data. A main finding, but based on a small number of subjects (N = 3) was that users had pre-dominant methods for solving tasks and would not change unless the method was found obviously inefficient.

Smith et al (1991) used a set of software tools similar to AESOP to record, replay and analyse users' online behaviour at the level of users actions, to help understand the strategies and behavioural patterns used to solve complex, open-ended tasks, such as planning and writing. In their paper they comment that an earlier version of the protocol analysis took a 'naïve assumption' that the duration of an event was the amount of time extending from the beginning of one event to the beginning of the next event. This however, they found to be inaccurate and that users often performed mental actions between events that did not result in computer actions. They concluded that,

> *"Pauses, thus, represent important information with respect to users' strategies and patterns of behavior that should be recorded for analysis."*

The same issue is brought up by Renniger et al. (1992), who looked at cognitive resource allocation in conjunction with the common assumption that the capacity of information-processing system has a finite limit. They comment that attention must be focussed on an object for a period of time that allows for cognitive processing to take place.

Magnusson (1996; 2000) also looks at behaviour, but following evidence that behaviour comprises of hierarchically composed temporal behavioural patterns, where larger patterns are built up from smaller ones, presents a computerised detection method (THEME) for the detection of these.

Folkard and Monk (1978) in their study looking at the effects of time of day on immediate and delayed memory comment that interest in the effects of time of day on memory originated out of practical implications for the scheduling of school subjects.

Early findings were that immediate recall such as digit span were better mid-morning, but perceptual-motor tasks were better in the afternoon (Gates, 1916, cited by Folkard and Monk (1978). Folkard and Monk's own study of the effect of time of day on immediate recall supported this finding, but they also noted that immediate recall worsened the higher the level of arousal, which follows the body's circadian rhythm for temperature. With the exception of a post-lunch 'dip', the body's temperature is at its lowest at around 04:00 and at its maximum at about 20:00 (Colquhoun, 1971 cited by Folkard and Monk (1978)

In other experiments, Folkard and Monk (1978) found that time of day did not affect recall from long term memory (LTM), but recall from LTM seemed to improve if the material had been learnt later in the day as arousal levels increased. Additional support for this comes from Revelle and Loftus (1992) who put forward evidence that high arousal assists the detection and encoding for long term retention of information.

Dunn and Dunn (1978) both in their own studies and in a review of other work on cognitive and learning styles found that students had a recognised preference for the time of day they studied. A few students also showed a preference for alternative teaching styles at different times or on different days. However, despite individuals having a preferred time of day for studying, Dunn and Dunn found no differences in academic performance between individuals who preferred studying in the morning to those who preferred studying in the evening.

There are however differences between Folkard and Monk's research and Dunn and Dunn's work. Folkard and Monk carried out a series of three controlled experiments looking at a definitive measure (short and long term memory). Dunn and Dunn, in contrast compared general academic ability (academic achievement) in relationship to the time of day students preferred to study. In addition, students in the studies by Dunn and Dunn would have been learning both at times of their choice (when doing homework or revising for exams) as well as studying at fixed times, during normal school hours, when attending lessons or lectures.

In relation to time of day, there are a number of studies that show that memory is *context dependent*, that is recall is better under the same external conditions that the information was encoded in (Baddeley, 1990, p 268-270). Closely related to this is *state dependent* memory which suggests that recall from memory is better under the same 'internal' or physiological conditions as the information was encoded (Folkard and Monk, 1978; Baddeley, 1990, p 271). Folkard and Monk go on to comment that the recall of information therefore may be better at the time of day it was encoded. However, they found no effect of state dependency in their study.

Adult distance education students often enrol on distance courses as it allows them to study materials in their own time and therefore at times they prefer, or find they are able to (Bååth, 1982). Bååth also found in his review of distance students' learning that the range of individual times students spent on work could be large, in one case the difference between the fastest and slowest student being 529 hours for a course that students on average spent 54 hours to complete.

One aspect of interest is whether distance education students taking the *M206 Computing: A Object Oriented Approach* course reflect Bååth's findings and whether they exhibit any common patterns in the time of the day, or day of the week in which they study. Another aspect of interest follows the implications between arousal and learning and long-term memory depending on the time of day. If students exhibit a common time of day at which they work does this have any implications for academic performance.

A feature of the AESOP Recorder and Replay tools (Chapter 2) is that every recorded action that a student carries out online in the M206 LearningWorks environment is automatically given a date and time stamp allowing various time values on both small and large scales to be measured. This feature was used in the following study to explore distance education students' behaviour in relation to time in the use of online computer based instructional material.

Participants

Distance education students taking the Open University's 2000 presentation of the course *M206 Computing: An Object Oriented Approach* were invited to take part in the study via the course's website. This website was accessible to all students taking the M206 course and was used to give out information about course changes and provide additional material. The invitation to take part in the study was posted at the same time that students received their course material in January 2000 (N = 3399). No incentive was offered to take part other than explaining the purposes of the study and that the results would be of use in improving the course for future students.

Method

Student participants who volunteered to take part were directed by a hyperlink to a web-based, pre-study Computing General Demographic Questionnaire – (CGDQ), described later, and asked to complete it in their own time. Participants had the option of completing the questionnaire either on- or off-line from the internet. The option to complete the questionnaire off-line was given to help students from incurring unnecessary costs if they accessed the internet through dial-up networking accounts.

Participants who submitted a response to the CGDQ (N = 368) were then sent the AESOP Recorder program files as an email attachment to install onto the machines they were using LearningWorks on. Periodically during their studies participants returned the recorded data from their machines as email file attachments. At the end of the course, in September, participants were invited by email to complete a modified, post-study version of the CGDQ, in order that a repeated measures comparative study could be conducted. This was felt necessary as some of the items measured by the CGDQ could change through participation in the course. Design of the CGDQ is discussed later.

Although each participant returned data for a number of LearningBooks (LBs), only the responses to LB 09 were chosen for analysis. LB 09 is early on in the course and structured such that it allows relatively little freedom for participants to deviate from the set tasks. Later LBs are more unstructured and dependent on the individual's choice of solution, such that the time differences measured in later LBs are likely to be due more to the size of the program designed to solve a task, rather than the individual's ability to work through a task.

Academic Attainment

Two measures of academic performance were used to assess whether the time of day that participants studied affected their academic achievement. The scores participants received for their first four Tutor Marked Assignments (TMAs) were used as a measure of academic ability with assessed work. TMAs are pieces of assessed work that participants complete in their own time, but are required to submit for marking by their tutor by set dates. Students are also given a traditional paper based examination at the end of the course and the overall examination mark achieved was used as a measure of academic ability in examinations. Participants' individual TMA scores and final exam marks were obtained with permission from the university.

The Computing General Demographic Questionnaire (see Appendix A)

The Computing General Demographic Questionnaire (CGDQ) was designed as a self-assessed inventory that could be completed online via a web-page. The overall number of questions were kept small to improve response rates (Courtenay, 1978; Labaw, 1982). Its intent was to gather data relevant to the present study which could not otherwise be obtained via the AESOP recorder, such as demographic data including, age (subjects were asked to respond by range), gender, postal code and occupation as well as the hardware configuration of the machine on which participants had installed LearningWorks.

The questionnaire also included a number of questions looking at issues that have already been noted or regarded as being able to influence participants' behaviour. These included prior experience of using a computer both at work and at home (Shashaani, 1994; Durndell et al., 2000), prior experience of programming, prior experience of taking Open University courses and the individual's level of comfort with carrying out various computing related tasks (Busch, 1995).

At the end of the course participants were asked to complete a modified version of the CGDQ, which had a number of questions added to gather feedback about participants experience of using AESOP.

A typographical error in the age ranges that affected anybody aged 20 from being able to select an age range was discovered in the published version of the pre-study CGDQ. The degree to which this affected the results is covered in the profile of participants.

A copy of the pre-study CGDQ is given in Appendix A and the post-study questionnaire is given in Appendix B.

Selection of time points

The use of specific actions or events to analyse the data has been defined in the introduction (Chapter 1) as *Event Protocol Analysis*. A problem experienced by others also using this method (Bates, 1988; Smith et al., 1991; Bates, 1995; Hilbert and Redmiles, 2000) and of relevance in this research, is in the selection of events, or points in time, in the data records which denote that a significant action has taken place.

To analyse the times and periods over which participants work we need to select those events in the data record which mark when a participant starts studying and when they stop. The M206 course is arranged so that students following it would, at certain points in the text of each chapter, be directed to look at or carry out the relevant practicals in the LearningWorks environment installed on the machine they are using. To be able to do this, students needed to initiate the LearningWorks software program and select, from the initial menu presented (the Launch window), the LearningBook (LB) they wished to study. The LB would then open in a new window displaying the *Practicals and Notes* contents page allowing the student to select the hyperlink to the practical they wished to attempt.

On completion of the work, students have the choice of either closing the LB directly or closing down the whole LearningWorks system via the Launch window. In both methods, students would be prompted to save any changes to the LB they had been working on. In addition, LearningWorks only allows one LB to be open at a time. It is impossible to have two LBs open at the same time.

A question that needs to be addressed is deciding when a participant actually starts or stops studying: Is it the time,

- when they start LearningWorks,
- when they open a LB, or
- when they start reading the instructions to the practical?

A similar problem lies in deciding when a participant stops studying.

The AESOP recorder, as already described in detail in Chapter 2, is invoked as soon as LearningWorks is initiated and only records activity within the LearningWorks environment. When a participant opens a LB the event `openUserVersion` is the first action recorded and is regarded as the point when the participant started using the LB material. All `openUserVersion` events were termed *Open* actions. When closing a LB, a sequence of three events commencing with `closeNoTerminate` was displayed in records as seen in Figure 3.1. Since participants had taken the decision to finish work at the event `closeNoTerminate`, and as the remaining closing sequence of events are within a very short space of this event, `closeNoTerminate` was designated as the point at which participants decided to stop using the LB. All `closeNoTerminate` events were termed *Close* actions.

In Figure 3.1, it can be seen that a subsequent *Open* action may follow a *Close* action, where a participant has, after closing a LB, opened it up again at a later point in time. A participant was therefore considered to be actively working on the LB between the point they opened it and the next subsequent point at which it was closed.

Observation of the data, and also reported by Thomas and Paine (2000b; 2002), revealed that participants left LBs open and inactive for long periods of time, up to 22.5 hours in one case. There were no methods available to this research to determine what participants were doing during these periods of "inactivity", such as reading the paper based course material, taking a break, a combination of the two or indeed something else entirely.

```
□openUserVersion:false□03/07/2000 11:55:15.000
□bounds:rectp404p289p876p735 window:i0/□03/07/2000 11:55:17.000
□bounds:rectp400p293p872p739    window:i0/LB-09    Smalltalk    Expressions:
□Practicals and Notes□03/07/2000 11:55:20.000
□bounds:rectp60p325p532p771 window:i0/LB-09 Smalltalk Expressions:  Practicals
and Notes□03/07/2000 11:55:34.000
□selectAnchor:c09s1.htm□03/07/2000 11:55:34.000
□detachPage□03/07/2000 11:55:39.000
□bounds:rectp404p303p876p722 window:i1/LB-09 Smalltalk Expressions: Practicals
and Notes: Practicals□03/07/2000 11:55:40.000
...
□closeNoTerminate□03/07/2000 14:01:59.000
□DIALOG:Save    LearningBook?    CHOICES:#('yes'    'no'    'cancel')□03/07/2000
14:02:01.000
□yes□03/07/2000 14:02:01.000
□openUserVersion:true□03/07/2000 14:49:31.000
□bounds:rectp404p289p876p735 window:i0/□03/07/2000 14:49:32.000
□scroll:p0p0 in:htmlView□03/07/2000 14:49:45.000
...
□closeNoTerminate□03/13/2000 14:31:31.000
□DIALOG:Save    LearningBook?    CHOICES:#('yes'    'no'    'cancel')□03/13/2000
14:31:33.000
□yes□03/13/2000 14:31:33.000
```

Figure 3.1: An edited Recording from a student highlighting the events used to define Open and Close actions.

In collaborative work with Thomas and Paine (2000b; 2002), a solution was found from the observation that a consistent trend emerged when increasingly smaller periods of inactivity were excluded from the calculation of total time taken to complete a LB. Figure 3.2, shows this in detail, where the mean total time for all students to complete a specific LB (no break) is plotted, then again when breaks exceeding 2 hours, 1 hour, 30 minutes, etc down to 1 minute are excluded from the total time taken by each student to complete a LB.

It was found that in all cases as the time differences that were excluded got smaller in size, the calculated time taken to complete a LB decreased. At around 5 minutes the graph for each LB appeared to flatten out and this was taken as a good estimate of the maximum time participants spent actively interacting with the LB as it also allows for thinking time as suggested by Renniger et al. (1992) and Singley et al. (1991). Work by Hutchings et al. (2004) in their studies of user modelling and VibeLog also use 5 minutes as the cut-off point, but they provide no validation for their choice of time limit.

The total period of time therefore that students were regarded as actively involved with their work is defined here as the *Total Active Time* (TAT).

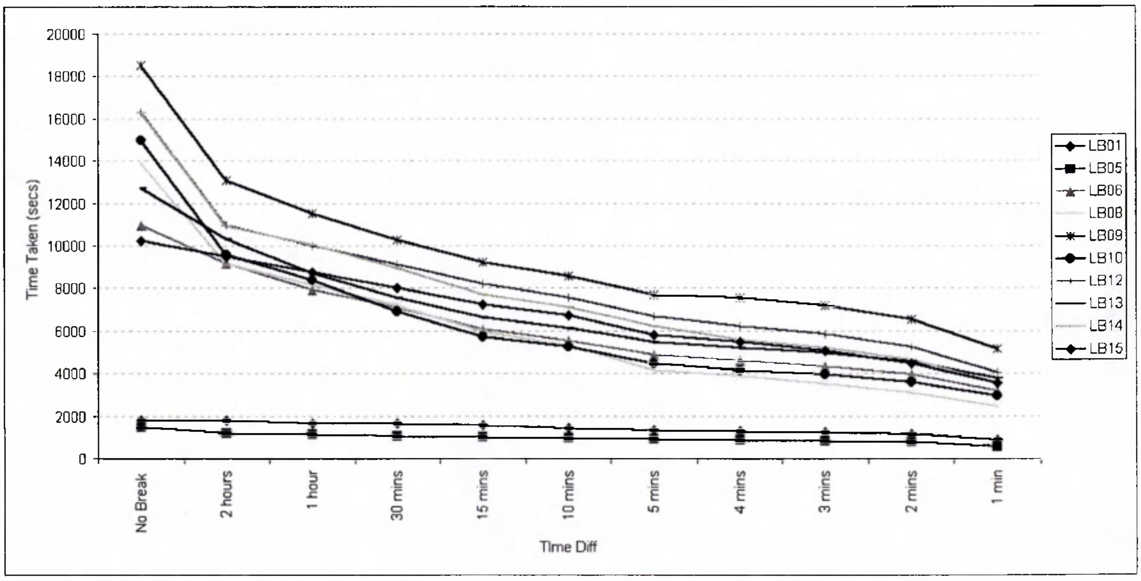


Figure 3.2: Comparison of mean time taken to complete LearningBooks 01 – 15, after differing lengths of time of time between events have been excluded.

Results

Participants

3399 students registered for the 2000 presentation of the M206 course. Of these 368 continued on to complete the pre-study CGDQ and 182 participants returned one or more recordings. 120 participants returned recordings for LB 09.

Analysis of the demographic data for those who had returned recordings for LB 09 indicated that the sample was a good reflection of the M206 course population with regard to distribution in age and gender (Table 3.1 and Table 3.2). Data giving the demographic distributions for each course is part of an ongoing internal monitoring of courses by the Open University and readily available through the university's intranet.

	LB 09 (n=120)	Course Total Population (N=3399)
Male	74.0%	79.1%
Female	26.0%	20.9%

Table 3.1: Comparison of study sample demographic data (Gender) against total course population

Some small differences were noted in the distributions indicating that participants tended to be slightly older and with a slightly higher proportion of females, however this was not found to be statistically significant for gender ($\chi^2 = 1.57$, 1 df, $p = 0.220$) or age ($\chi^2 = 8.41$, 6 df, $p = 0.154$).

	LB 09 (n=120)	Course Total Population (N=3399)
under 25	5.4%	10.7%
25-29	14.3%	19.6%
30-39	43.7%	42.9%
40-49	29.1%	20.0%
50-59	6.3%	5.7%
60-64	0.9%	0.7%
65+	0.3%	0.5%

Table 3.2: Comparison of study sample demographic data (Age) against total course population

A typographical error in the age ranges of the published pre-study CGDQ, precluded those aged 20 from being able to select an age category. However, of the 120 participants had returned recordings for LB09 and completed the questionnaire, all 120 had answered this question and of these only a small percentage appear to have been affected (4.9% said they were ages 21-26 and 0.8% said they were aged under 20). Because of the limited age range that was affected within a small section of the sample it is felt that this error did not unduly affect the results by any significant amount. In addition to which the data was used to gain information on the comparability of the sample against the course population rather than as a factor in its own right.

Sittings

A *sitting* is defined as a period of time that a student interacted continuously with the computer without a significant break in activity. Breaks in activity were taken as any gap between two successive events greater than a specified period of time. The definition of *sitting* was developed in research work parallel to this by Thomas and Paine (2000b), but is described here because of its relevance and use in this work.

Chronological Timelines

As a method of looking at the overall pattern of an individual's sequence of opening and closing events, each open and close event was plotted sequentially on a time line (*x* axis) with the date and time for each event plotted against the *y* axis as shown in Figure 3.3. A sample of 15 records showing the main characteristics displayed by participants is shown, as it was found that plotting all 120 time lines on the same graph made the display too complex.

It is worth noting that although students are encouraged to work at their own pace, there is a course calendar that details the dates over which students are advised to study the different parts of the course. There are no gaps (such as revision breaks) between chapters, so Chapter 09 (with which LB 09 is associated) would immediately follow Chapter 08. In the year 2000 students would have been expected to be seen studying Chapter 09 during the period 4th – 11th March. In addition to this, students are expected to have completed those chapters which precede a TMA by the specified cut-off date – the date on which it should be completed and sent in for assessment. In this case

Chapter 09 precedes TMA 2, so we would not expect students to still be using LB 09 after 13th April, which was the cut-off date for the year 2000 presentation of the course.

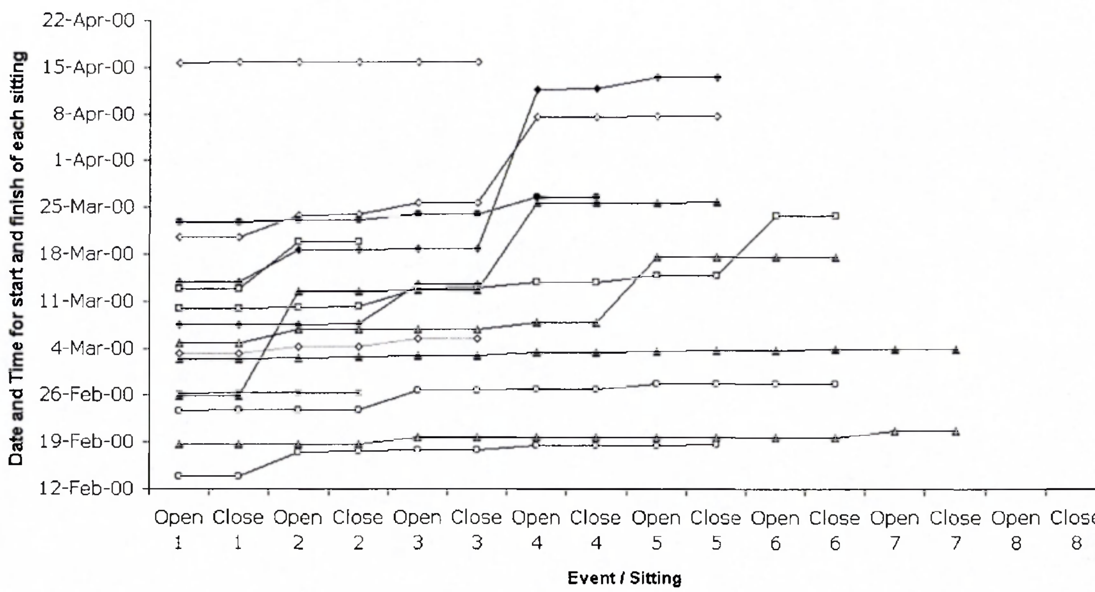


Figure 3.3: Representative sample of 15 individual timelines showing sequential opening and closing of LB 09.

From the sample of 120 records received there was a large variation (in relation to the course calendar) in the dates over which students started working on LB 09. The start dates ranged between 10 February, 2000 to 16 April, 2000 (*Average starting date* = 6 March, 2000, *standard deviation* = 11.8 days). However, participants were also noted to have generally completed studying LB 09 in time for handing in TMA 2 (taking into account that some were granted a few days grace for completing the work). The full range of dates is not shown in Figure 3.3 as this is only a representative sample.

The total period of time (not Total Active Time (as defined earlier)), between the first instance of opening up LB 09 and the last instance of closing it down, over which participants took to complete LB 09 was also found to vary considerably (*min.* = 3 minutes, *max.* = 54 days, mean = 8.86 days, *sd* = 9.85 days,). This is consistent with the findings by Bååth (1982) that distance education students varied considerably in the amount of time they took complete work.

It was initially thought through initial observation and analysis of the data that there were three discernible patterns in the way that participants worked through LB 09. These patterns can be seen in Figure 3.3 and are

- One group of students who worked through the LB within the same day.
- A second group who completed the LB within 2 to 3 days, doing some of the LB in one day and then returning and completing it over the next day or two.
- A third group that took 7 or more days to work on the LB, who also left longer breaks of 7 days of more between *sittings*.

As one of the objectives of the research within this thesis was to identify potential behavioural patterns that could be used to classify types of learners, the data was re-examined in detail. Figure 3.4 shows the frequency distribution of the total number of different days that students worked to complete LB 09.

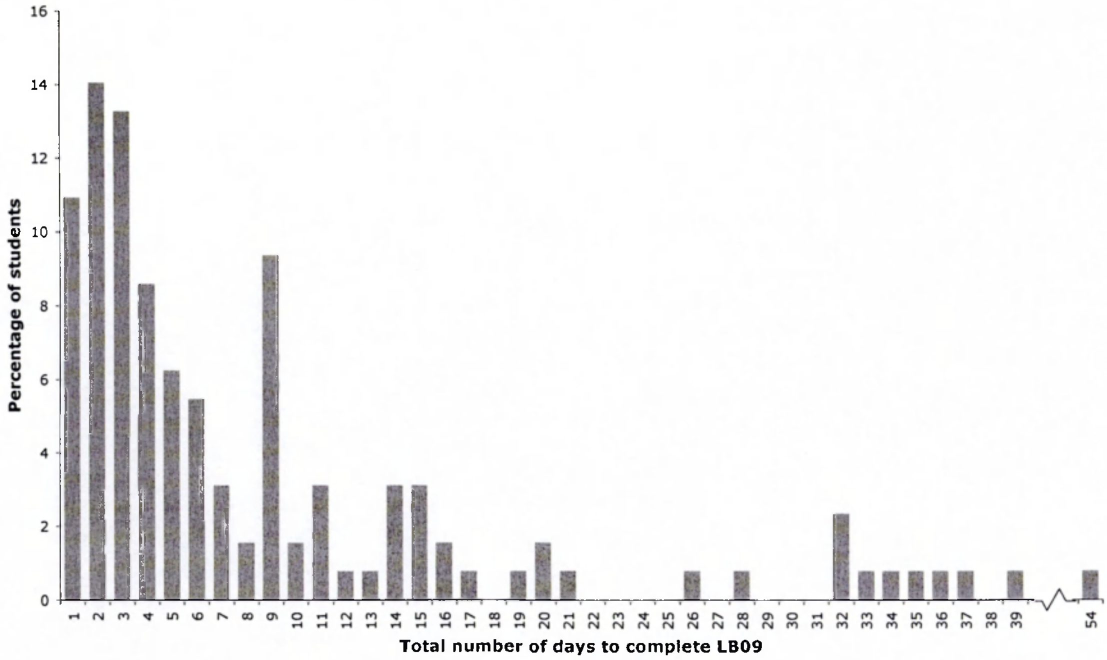


Figure 3.4: Frequency distribution of the total number of days students were found to take to complete LB 09.

As well as the total number of different days worked, the number of days not worked between individual *sittings* was also considered as a factor. However, as Table 3.3 shows, there is no pattern between the total number of days an individual would take to complete the work and the largest break (in days) they included while doing so.

Total Num of days taken to complete LB 09 (n = 120)	**Frequency count of the largest break taken by each student between sittings (whole days)**								Total
	0 days	*1 day*	*2 days*	*3 days*	*4 days*	*5 days*	*6 days*	*7 or more*	
1	11	-	-	-	-	-	-	-	**11**
2	-	14	-	-	-	-	-	-	**14**
3	-	9	7	-	-	-	-	-	**16**
4	-	4	6	1	-	-	-	-	**11**
5	-	1	5	1	1	-	-	-	**8**
6.	-	1	1	2	2	1	-	-	**7**
7	-	-	-	-	2	1	1	-	**4**
8	-	-	-	1	1	-	-	-	**2**
9	-	-	-	1	3	2	3	3	**12**
10 or more days	-	-	-	-	1	1	4	29	**35**
Total	**11**	**29**	**19**	**6**	**10**	**5**	**8**	**32**	**120**

Table 3.3: Table detailing the number of students taking largest break between sittings (in days) compared against the total number of days taken to complete LB 09.

From this it was noted that the data did not support this original premise and that there were no unique behavioural patterns with regard to the total number of days in the time taken to complete LB 09.

Preferences for time of day and day of week to work.

A frequency analysis was carried out on the time and date data of LB 09 to determine if there was any consistency in the time of day or day of week that individual participants were seen to start work and if there was a preference for the group as a whole for particular times or days. The start time was taken as being the day and time that participants were seen to start their work most often, but it does not necessarily indicate this was the best time for the individual participant or indicate the level of desire by a participant for working on that day or at that time.

The time at which each participant started a *sitting* was used to denote the time they chose to start work. A *sitting*, as previously defined, is a period of time spent continuously studying without a significant break in activity. For this analysis a significant break in activity was regarded as 2 hours, such that if a participant took a break of 2 hours or more, they were regarded as having stopped one *sitting* and to have started *another*. Figure 3.5 shows the resulting frequency distribution of the day of the week worked using the most frequent starting day of the week for each individual participant.

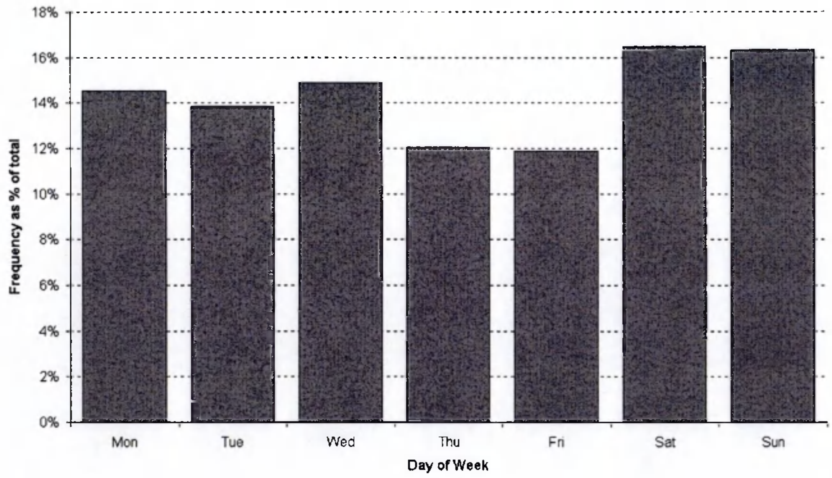


Figure 3.5: Frequency distribution of preferred day of week for working by participants

Examination of the raw data for LB 09, however, showed that the initial premise that individuals have a chosen day of working during the week was flawed, as participants who were noted to work on several days, did not appear to be selective as to the day of the week they worked or even during specific periods of the week, for example weekends versus weekdays. To resolve this and build a more accurate picture of when participants work, the data was re-analysed to allow each separate day that individuals were seen to be working on to be represented in the final frequency analysis. Again successive events closer than two hours were excluded and each individual day was represented only once. For example if a person completed a *sitting* early on a Monday then later in that same day completed another *sitting*, then Monday would be represented only once. However, if they completed a *sitting* on the Monday in one week and then completed another *sitting* in the Monday of the following week, then Monday would be represented twice.

Figure 3.6 shows the corrected frequency plot of day of week chosen by participants to work. What is apparent from both Figure 3.5 and Figure 3.6 is that distance education students as a group show no preference for certain days or periods of the week in which to work. While there appears to be a mild trend for participants to work early on in the week (Sunday – Wednesday), there is no significant difference in distribution found between individual days ($\chi^2 = 3.847$, 6df, $p = 0.697$), or between working weekdays in comparison to weekends ($\chi^2 = 0.200$, 1df, $p = 0.655$). A significance for a specific period of the week would have indicated the need for distance education courses to concentrate their tutoring and other human resources on those days.

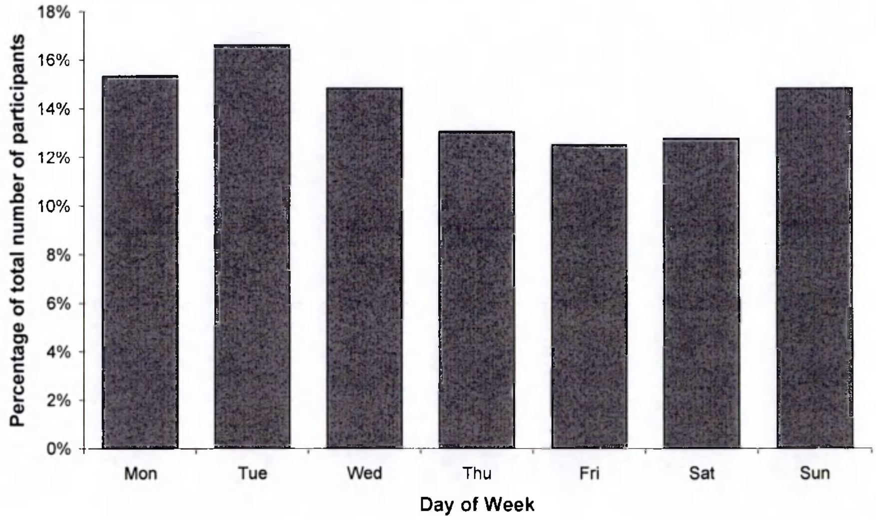


Figure 3.6: Corrected frequency distribution of preferred day of week shown by participants for studying. Frequency is shown as percentage of total.

Using the same technique employed to determine the day of the week that participants worked, frequency distributions of the time of day participants chose to start studying (opened LB) and stop studying (closed LB) were plotted along the same 24 hour scale (Figure 3.7).

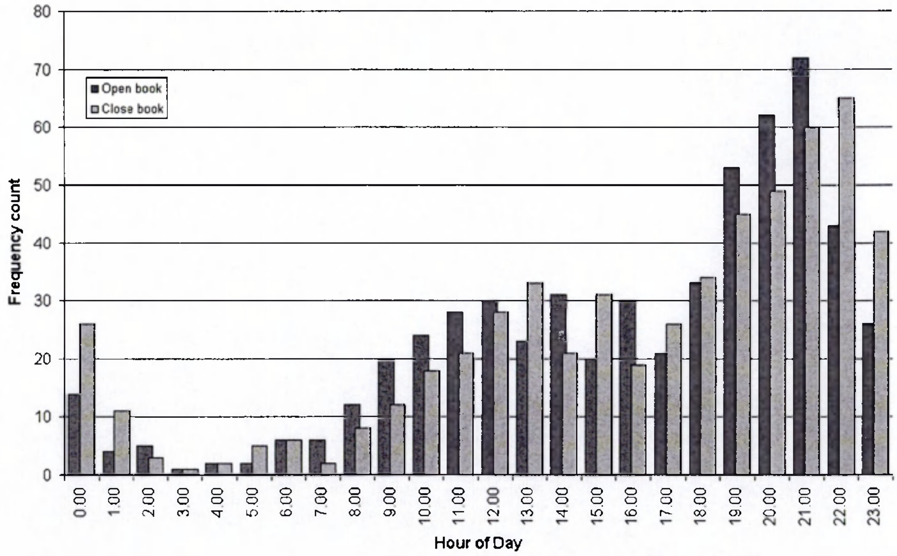


Figure 3.7: Frequency distribution showing participants usual (median) time for starting (Open) and finishing (Close) studying.

However, as well as participants being noted to work at all hours, there was a general trend towards working in the evening, peaking at 21:00 for starting work and 22:00 for finishing work with a smaller earlier peak at lunch time (12:00) for starting and 13:00 for finishing. These observations have a number of implications which are considered in more detail later in the discussion.

Effect of hardware on time taken to complete LBs

Earlier studies have shown that differences in hardware configuration can affect individuals' performances while using computers, such as reading speed (Gould, Alfaro, Barnes et al., 1987; Gould, Alfaro, Finn et al., 1987; Kingery and Furuta, 1997). Using the information that participants gave about their hardware profiles on the General Demographic Questionnaire, various factors such as screen size, resolution, RAM and processor were examined and compared against the total active time (TAT), described earlier, taken to complete LBs. For these analyses LBs other than 09 were also included to gain a more complete picture.

Screen Resolution vs Time to Complete Work.

Figure 3.8 shows the relationship between screen resolution and the TAT taken by participants to complete LB09.

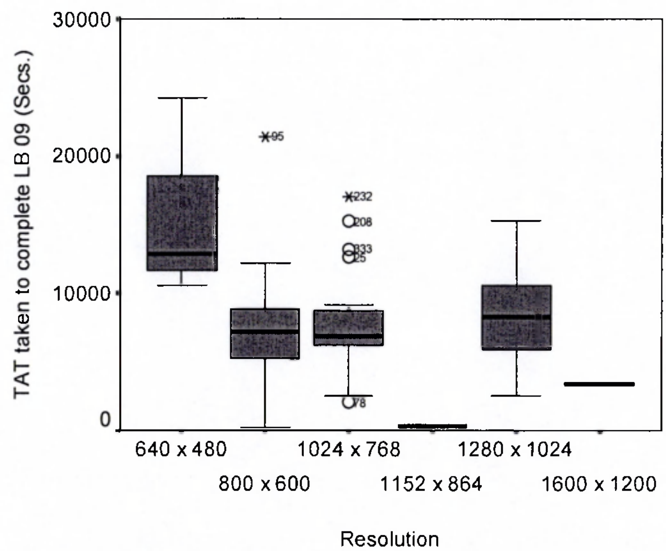


Figure 3.8: Box plot showing distribution of total active times (in seconds) taken by participants to complete LB 09 for various monitor resolutions being used (pixels).

Both the box plot and subsequent analysis of variance found that participants using a screen resolution of 640 x 480 pixels took significantly longer to complete LBs 09 ($F = 3.338$, 5 df, $p = 0.011$) and LB 10 ($F = 3.177$, 5 df, $p = 0.013$). Although later LBs (LBs 12 - 14) were also noted to follow the same trend, the trend was less pronounced and not found to be statistically significant (Table 3.4). This is possibly because the tasks are less structured in the later LBs and therefore users show a greater natural variation in the times they take to complete them, regardless of the screen resolution.

A possible reason why those using lower resolution monitors took much longer complete LB 09 and LB 10 was that their hardware specification was much slower than those using higher resolution screens, however it was subsequently found that this was not the case. There is also anecdotal evidence that those using high performance machines with monitors capable of resolutions up to 1024 x 768 pixels are still known to use their screen at a low resolution (Clover, 2000). The possibility of those using lower resolution screens having had less computer experience was also explored, but 66% of those who used 640 x 480 pixel resolution said they had previous computing course experience. This implied that there was another reason for why those using screens at 640 x 480 pixel resolution were much slower at completing the LBs.

ANOVA		df	F	Sig.
LB 09	Between Groups	5	3.338	0.011
LB 10	Between Groups	5	3.177	0.013
LB 12	Between Groups	5	1.595	0.179
LB 13	Between Groups	5	1.134	0.353
LB 14	Between Groups	5	1.389	0.245

Table 3.4: F values and levels of significance in an analysis of variance carried out comparing total active time taken to complete LBs between different levels of resolutions in use.

Subsequent investigation using the AESOP Replayer found that those using screen resolutions of 640 x 480 pixels frequently had to change between overlapping windows, one showing the instructions (*Practicals and Notes*) and the other showing the LB's *Workspace* and *World.* Users of higher resolution graphics were able to place these windows side by side and view both at the same time, see Figure 3.9 and Figure 3.10.

However, an additional reason why students would take longer when they have to keep switching between windows is provided by *Cognitive Load Theory* (Sweller, 1988), as a greater load is placed on working memory, since the user has to remember the information that was in the previous window. This takes up working memory resources and as a result leaves less working memory available for the cognitive tasks of selecting, organising and integrating involved with the process of learning.

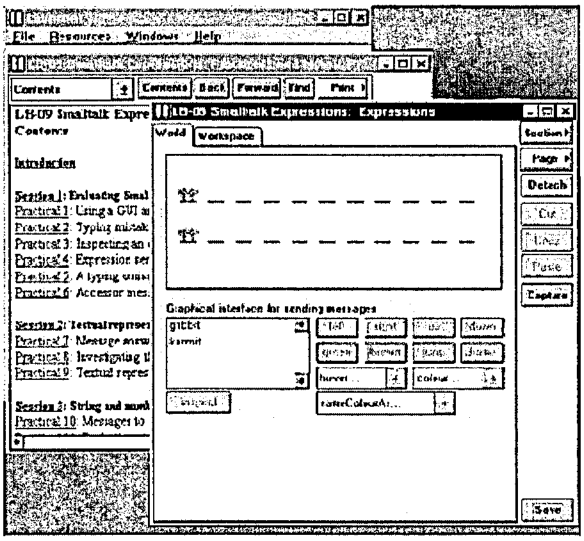


Figure 3.9: Screen shot of LB 09 being used on a screen at 640 x 480 pixels resolution, showing overlap of World and Workspace with Practicals and Notes page.

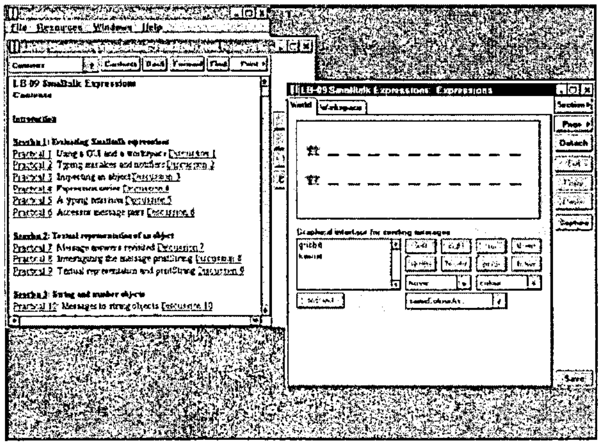


Figure 3.10: Screen shot of LB 09 being used on a screen at 800 x 600 pixels resolution, showing view of Practicals and Notes page along side World and Workspace.

Time of Day preference relationship with academic outcome

Because earlier studies have shown that time of day can affect academic performance (Folkard and Monk, 1978), it was considered worthwhile investigating if the range of times chosen by students to work affected their academic performance.

Students' records for completing LB 09 were first analysed to establish the amount of variation that each individual displayed in the time of day they choose to work. Using the time of day that LB 09 was opened for each *sitting* as the indicator, individuals who completed LB 09 in four or more *sittings* were analysed. Of the 120 records available for LB 09, 72 records met this criteria. For these individuals, the mean and standard deviation of the times of day that each one started work on LB 09 was calculated. Figure 3.11 shows a plot of the calculated mean and respective standard deviation for each individual, with individual means sorted in ascending order.

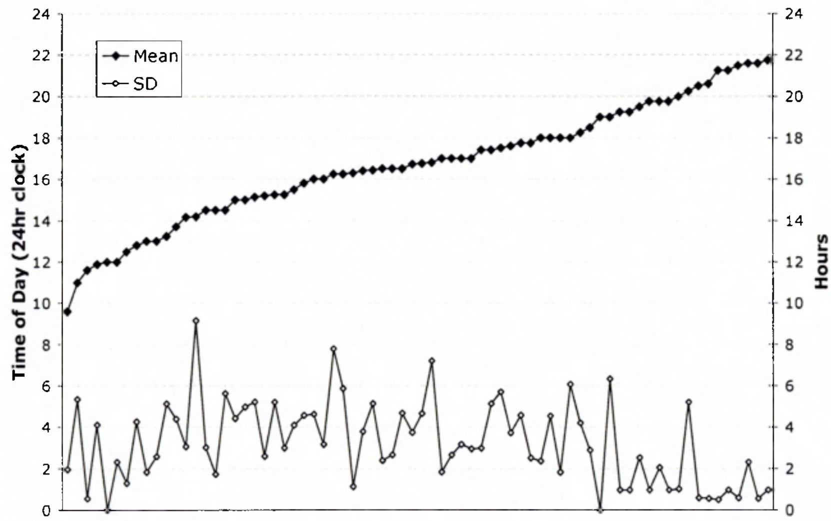


Figure 3.11: Mean time of day (24 hour clock) compared against the standard deviation (hours) in time that individuals were found to start working on LB 09. Individual's mean and standard deviation are plotted relative to each other.

From this it can be noted that, as well as the considerable variation between individuals in the time of day chosen to work, individuals were also noted to show considerable variation in the times that they started work on LB 09. However, there is a tendency for the variation (as indicated by the standard deviation) to decrease as the mean of the time of day that individuals start to work increases. This is particularly evident from 19:00 in the evening suggesting that those who generally started to work on LB 09 in the evening after this time had a more regular study time habit, while those whose mean time was found to be during the day are more flexible in the hours that they start work.

To find out if academic performance was affected by working at a particular time of day, those individuals who were noted to work at around the same time each day were selected. To select these individuals the mean of all the individual standard deviations was 2.9 hours. Using this as a guide, those individuals with a standard deviation of less than 2.9 hours were selected and the mean time of day correlated against the score obtained for TMA 2.

TMA 2 (Tutor Marked Assignment) was chosen as the academic measure as the assignment is relevant to LB 09 and also requires LB 09 to be completed. TMAs are also completed in students' own time, and as those individuals selected for analysis had shown they started work on LB 09 at a relatively consistent time it was presumed that these students would also have worked on TMA 2 at similar times of the day they would normally have worked on LB 09.

A Pearson correlation was carried out on 36 records that met the criteria, but it was found that time of day did not affect academic performance in the sample selected ($r_{pearson} = 0.151$, $p = 0.410$). One consideration with this result was whether the variability in the range of times chosen might have been too large. To test this individuals who had a standard deviation of 1 hour or less and therefore studied at much more regular times were selected. However, it was again found that time of day did not affect academic performance. The Pearson correlation was significant ($n = 14$, $r_{pearson} = -0.605$, $p = 0.022$) but this significance was found to be purely due to an outlier.

Discussion

Practical considerations

During the course of the investigations two practical considerations came to light regarding the audit trail created by the AESOP Recorder.

The date and time stamp created for each event recorded is reliant on the accuracy of the system clock of the participant's machine, and it was noted that some recordings received did have date and time stamps referring to previous years. Measurements such as the TAT used the time differences between events within recordings and were therefore not affected by this, however for other measurements such as time of day, day of week and dates on which work was carried out, it was assumed that the system clock on a participant's machine was accurate unless the date displayed preceded January 2000, which was before course material and the AESOP Recorder would have been received. Those cases which preceded this date were not included in the relevant analyses.

A way of compensating for this in future work would be to ask all participants at the start of the study to ensure that the system time on their machine was accurate. Offering access to utilities that would keep the system's clock accurate such as Chronograph Atomic Time Clock Lite (*Chronograph Atomic Time Clock Lite,* 2003) may help. Another possibility is the inclusion within AESOP of a similar utility that could either change the system time and/or record the difference between the system time and the actual time, depending on the user's preference. For this study and others that rely on the accuracy of the system time, a large scale survey of the accuracy of system clocks would give a useful indication of the margin of error to be expected in future studies.

In a few records it was also noted that there would be an *Open* event but no preceding *Close* event, indicating that a LB had been opened, but the Recorder had failed to record any events leading to the LB being closed or the LearningWorks environment being terminated. In cases where this was noted to happen the recorded event immediately preceding the *Open* event was taken as the *Close* event.

Total Active Time

A useful improvement to future studies from this research was the development of the measure *Total Active Time* (TAT) taken to complete work. Some studies, such as McWilliams (2001), have only looked at the total amount of time students have spent completing work, but not accounted for the time taken for breaks, etc. The TAT in this regard is therefore more accurate and by including all breaks in activity of up to five minutes, still allows for the TAT to include to some extent those cognitive processes or 'thinking time' other researchers regard as important to the process of learning (Renniger et al., 1992; Smith et al., 1993).

Students' use of time to study

These findings corroborate with Bååth's (1982), that there was a marked variation between individual distance education students in the amount of time they spent completing the online study material, as was the number of sittings they took to complete it. Students took between 1 to 32 sittings to complete LB 09. Most completed the work in 4 sittings, which is the number of sittings a student is expected to take if they followed the course instructions for LB09. In addition, this study found considerable variation in the range of dates over which distance education students started to work with the LB, and also in the time of day and day of week on which they chose to work.

Distance education students on M206 were found to work mainly at lunch time and in evening, the peak time for starting work being around 21:00 and the peak time for finishing work being 22:00. If this pattern of study is generalisable to other distance education courses, it has implications for the organisation of those courses that wish to provide real-time access to discussions or perhaps live lectures, as it appears the best time to meet the need of most students is to have this material accessible in the evening rather than during the day.

The pattern in the time of day that students were found to work and the degrees by which this time varies during the day, suggests that the time students study at are constrained by their lifestyles. An example being the rise of students studying from 5pm and those working in the evening having less variability in the time they start working. This corresponds with students who have an approximately 9 am to 5pm working day. This however, is conjecture and requires further work to confirm how students lifestyles affect their pattern of work.

Academic implications of time of day chosen to study

Folkard and Monk's (1978) work found that immediate recall from memory is easier earlier in the morning, but that items encoded later in the evening were easier to recall from long term memory at a later date. This suggests that the time of day individual students study could have implications for learning the material and being able to recall it later.

In this study, time of day was not found to affect academic performance on TMA 2. Although the effect of time of day on memory could have been a possible factor to consider, students had ready access to the original LBs and therefore did not need to rely on long term memory.

Conclusion

This research has investigated a number of ways in which distance education students behave in relation to time and whether this has an impact on academic performance. The time distance education students took to complete work was found to vary considerably. However, although individual students differed a great deal in the time taken to complete the work, virtually all completed it by the date set by the course. These findings are consistent with Bååth (1982) who also noted significant differences in the time distance education students took to complete work. The findings also show that students do complete work by an allotted date, although there is a large amount of individual variability over the time taken and temporal sequence in which this is achieved.

Students were also noted to vary in the time of day they started, as individuals and as a group. As a group, the peak time that students started to work was around 21:00, with a smaller peak at around lunchtime. There was also considerable individual variation in the times that students started work, with individuals' variation reducing as the mean of the times of day they were noted to start working became later. This corroborates anecdotal evidence and other research (Dunn and Dunn, 1978; Bååth, 1982), that distance education students work at the times most convenient to them and follow individual study patterns. However, the time of day that students chose to work had no impact on academic performance on assessed work.

A positive finding was that students using visual display units at a low resolution 640 x 480 were significantly slower completing LBs, spending a greater time actively carrying out the tasks requested. These students did not have significantly slower machines and it was noted the slowness was due to the layout of the CBI material on the screen and inability for users of 640 x 480 screens to separate the windows enough to read the text and type in the workspace without having to swap between windows.

Chapter 4.

Distance Education Students' Levels of Comfort with Computing Related Tasks

Abstract

This chapter looks at the relationship between students' levels of comfort carrying out computing related tasks with online behaviour and academic performance. The level of comfort with computing tasks expressed at the start of the course was found to be related to the time students took to complete tasks as well as their assessed work and final exam performance. Prior experience with programming was also found to be a significant factor. Implications are discussed which include the possible need to identify and provide additional, directed support to those who are less confident.

Introduction

There is considerable evidence to show that self-confidence and performance in a task are closely related and affect each other. Individuals with low self-confidence are known to do more poorly at a task than individuals with more self-confidence, however doing poorly at a task can also reduce an individual's self-confidence and vice versa (Casey et al., 2001; Grandjean et al., 2002; Zorkina and Nalbone, 2003).

AESOP (An Electronic Student Observatory Project) is a project that allows asynchronous, remote observation of distance education students' online behaviour to be undertaken (Logan, 2000; Thomas and Paine, 2000b; 2000a; 2000b; Logan and Thomas, 2001b). A concern of the AESOP study was that students' self-confidence could be a factor influencing their observed, online performance or behaviour and whether the amount of confidence expressed at the beginning of the course might therefore be related to the final examination outcome. An additional factor was to also look at differences between the genders following frequent anecdotal reports and studies that females often express less confidence than males with computing related tasks (Shashaani, 1994; Busch, 1995; Corston and Colman, 1996; Comber et al., 1997; Durndell et al., 2000).

To address these issues, participants were asked about their levels of comfort, as a measure of self-confidence, in carrying out various computing related tasks at the start and end of the study. The results and implications of the findings are discussed.

Participants

All participants were student volunteers from the 2000 cohort of the Open University's distance learning course *M206 Computing: An Object-Oriented Approach* (*The Open University,* 1998b; The Open University, 1998a). Students were invited to complete a pre-study questionnaire when they received their course material in January and then again close to the end of the study. No incentive was offered to students other than explaining the purposes of the study. 368 students volunteered to take part and completed the pre-study questionnaire, of these 345 answered the questions looking on levels of comfort and 182 out of 345 returned one or more recordings. 81 students carried on to complete the post-study questionnaire.

Method

Two sets of questionnaires, a pre-study and post-study questionnaire, were made available to participants to complete online via a web page before and after the M206 course respectively. The pre-study questionnaire was designed to collate and monitor information that the AESOP recorder was not designed to capture, such as participants' demographic details (age, gender, occupation), prior computing and programming experience, as well as specific information about the specification of the computer they were using to study the course.

As a way of assessing how comfortable participants were with various computing related tasks, five questions relating to different aspects of using computers were included on the pre-study questionnaire (Table 4.1). Participants were asked to rate on a scale of one to five (with one being lowest and five highest) how comfortable they felt carrying out each task.

How comfortable are you with:	
a)	**Using different kinds of computing applications?**
b)	**Using programming languages?**
c)	**Using the internet?**
d)	**Using electronic conferencing or e-mail?**
e)	**The process of software installation?**

Table 4.1: Questions used to elicit participants levels of comfort with various computing related tasks.

The post-study questionnaire was aimed at gathering feedback from the students about the AESOP study as well as repeating questions from the pre-study questionnaire to allow a comparison to be made with the first questionnaire in a repeated measures design.

Results

<u>*Pre-study*</u>

Gender Differences

345 students (Male = 254, Female = 91) completed the pre-study questionnaire. An analysis comparing the distribution of expressed levels of comfort between the genders

found significant differences between males and females on all tasks except for use of electronic conferencing or e-mail (communications) (Table 4.2).

	Pre-study comfort with applications	Pre-study comfort with programming	Pre-study comfort with internet	Pre-study comfort with communications	Pre-study comfort with installing
Mann-Whitney U	8872.000	9675.500	10115.500	10521.000	8245.000
Wilcoxon W	13058.000	13861.500	14301.500	14707.000	12431.000
Z	-3.822	-2.622	-2.116	-1.591	-4.716
Sig. (2-tailed)	$p < 0.0001$	$p = 0.009$	$p = 0.034$	$p = 0.112$	$p < 0.0001$

Table 4.2: Comparison of expressed levels of comfort in various computing related tasks between genders.

These results are expressed graphically in Figure 4.1, where it can be seen that, with the exception of programming, both sexes have very similar frequency distributions, with the vast majority of males and females generally choosing to state that they are either 'very comfortable' (rated as 5), 'comfortable' (rated as 4), or 'fairly comfortable' (rated as 3). Males predominantly expressed that they are 'very comfortable' while females generally expressed lower levels of comfort which, as noted above, was significant in many cases. It is of interest that there is no linear relationship between the 3rd and 5th category in any measures. The possibility of a response set was considered, whereby participants' show a tendency to use the same value for all answers, however there was a very different distribution expressed by males and females with regard to comfort with programming, which would indicate that participants were not following a set pattern of response and were considering their answers.

On programming tasks, both genders again follow similar patterns to each other but express far less levels of comfort than with the other tasks. An inversely proportional relationship is generally seen, with a high proportion of each gender expressing the lowest levels of comfort, 'Very uncomfortable' (rated as 1), and then the number in each gender becoming increasingly smaller the higher the level of comfort expressed.

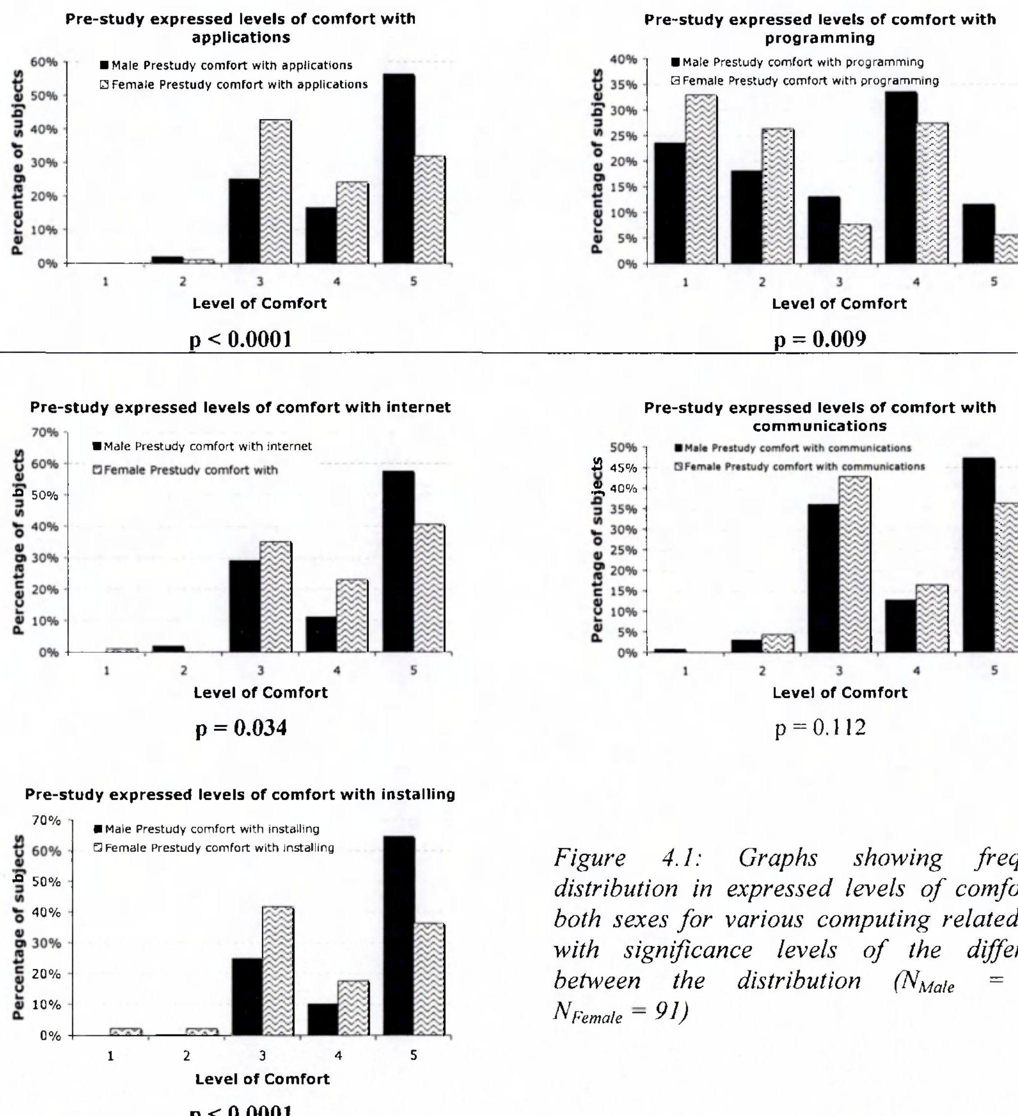


Figure 4.1: Graphs showing frequency distribution in expressed levels of comfort for both sexes for various computing related tasks with significance levels of the differences between the distribution (N_{Male} = 254, N_{Female} = 91)

There are greater numbers of females than males at the lowest levels of expressed comfort. A large percentage in both genders however, indicate they are 'fairly comfortable' (rated as 4) with programming tasks, creating a second peak. For males this is the largest majority and for females the second largest majority after 'very uncomfortable'.

Detailed examination of the data, checking for response sets, found that those who rated their comfort of programming as 4 had representative distributions on the other measures and the second peak was due to a difference between individuals who had indicated they had prior programming experience and those who had not had prior experience. Those with prior experience of programming were also found to have significantly higher levels of comfort with this task than those without prior experience (($n_1 = 135$, $n_2 = 215$), $U = 3748.000$, $p < 0.0001$)(Figure 4.2).

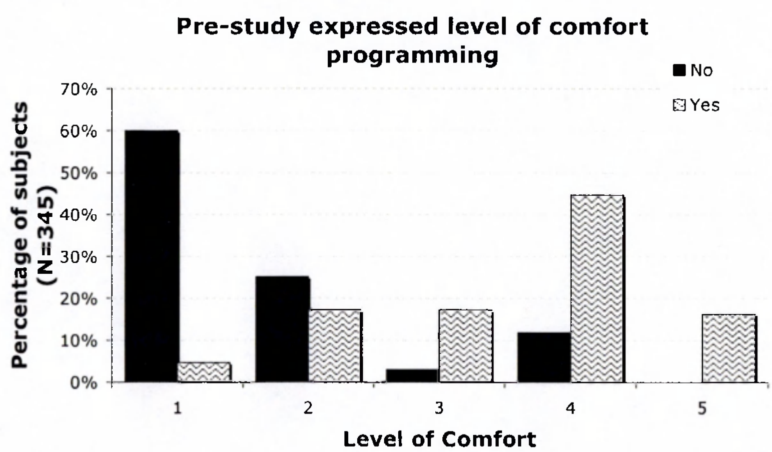


Figure 4.2: Comparison of expressed levels of comfort in programming between individuals who have had prior experience of programming and those who had not.

Levels of Comfort and Observed Online Behaviour.

One measure used to look at online behaviour was the effective 'Total Active Time' students spent working on each LB (a set of exercises associated with each chapter of the course). As discussed in Chapter 3, it was found that many students had a number of long periods of time in their recordings when there was no apparent measurable online activity while a LB was open and in use. This lead to the amount of time remaining after removing any periods of inactivity over 5 minutes being designated as the 'Total Active Time' (TAT), or a measure of the total amount of time students are felt to have been actively working on the material.

For this study, the TAT for LearningBook 9 was again selected as this material was far enough into the course to involve some programming, but structured enough to provide a common set of tasks requiring set responses. In later LearningBooks (LBs) students have greater personal freedom in the interpretation of the tasks and therefore greater variability in the amount of time the task could take.

123 students (Male = 91, Female = 32) had returned records for LB 9 and completed the pre-study questionnaire.

Total Active Time completing LB 9		Pre-study comfort with applications	Pre-study comfort with programming	Pre-study comfort with internet	Pre-study comfort with communi-cations	Pre-study comfort with installing
All	r_s	**-0.305**	**-0.241**	**-0.288**	-0.154	**-0.250**
(n = 123)	Sig.	p = 0.001	p = 0.007	p = 0.001	p = 0.088	p = 0.005
Males	r_s	**-0.286**	**-0.223**	**-0.240**	-0.232	**-0.225**
(n = 91)	Sig.	p = 0.006	p = 0.033	p = 0.024	p = 0.027	p = 0.033
Females	r_s	**-0.368**	-0.319	**-0.425**	0.024	**-0.358**
(n = 32)	Sig.	p = 0.038	p = 0.075	p = 0.015	p = 0.895	p = 0.044

Table 4.3: Correlations of Total Active Time spent completing LB 9 with pre-study levels of comfort expressed carrying computing related tasks. Significant correlations are in bold type.

There were, in most cases, small, but significant negative correlations between individuals' TAT and the level of comfort expressed (Table 4.3), indicating that those who were less comfortable at the start of the study carrying out various computing related tasks generally took more time to complete LB 9. These correlations do not appear to be gender specific although the correlations for females are a slightly stronger than for males, and in the case of comfort with programming, only males have a significant correlation. Further study is desired before a conclusion can be brought, but as the significance level for females lies just outside of the 5% level for comfort with programming, it is felt these variations are due mainly to the difference in numbers of male and female subjects, rather than other factors.

Comfort and Academic Performance

The fact that students' levels of comfort at the beginning of the course was found to correlate with the time it takes to complete a LB, a behavioural performance measure, raises the question of whether comfort has relationships with measures of academic performance such as grades for continuous assessment and the final examination.

Continuous assessment of students' work is carried out through Tutor Marked Assignments (TMAs). TMAs are pieces of practical work set a certain points during the course that need to be `completed and submitted within a fixed period of time. TMAs are marked by the tutor responsible for the individual and count towards the final mark given to the students. Students also get a conventional written exam at the end of the course.

Students' final examination scores, cumulative TMA scores (continuous assessment) and final overall marks were obtained from university records and compared against the students' expressed level of comfort at the beginning of the course. To maximise the data set available for analysis, all students for whom this data was available were selected (N = 236). The results are given in Table 4.4.

N = 236		Comfort Applications	Comfort Programming	Comfort Internet	Comfort Communications	Comfort Installation
Assessed work score	r_s	0.069	**0.155**	0.074	-0.007	-0.001
	Sig.	p = 0.288	p = 0.017	p = 0.259	p = 0.913	p = 0.993
Exam mark	r_s	0.050	**0.160**	0.008	-0.043	-0.046
	Sig.	p = 0.442	p = 0.014	p = 0.902	p = 0.515	p = 0.480
Final mark	r_s	0.069	**0.150**	0.038	-0.027	-0.025
	Sig.	p = 0.291	p = 0.021	p = 0.561	p = 0.686	p = 0.698

Table 4.4: Correlations between post-study levels of comfort with various computing related tasks and measures of academic performance. Significant correlations are in bold type.

In general there were no correlations between participants expressed levels of comfort at the start of the course and their final examination mark or final TMA score. However, small but significant positive correlations were found between the level of comfort expressed by students for programming at the start of the course and their final exam mark ($r_s = 0.160$, $p = 0.014$) and continuous assessment score ($r_s = 0.155$, $p = 0.017$).

The relationship between comfort with programming and final exam outcome was explored further using prior experience of programming as a factor. A highly significant difference was found to exist between those with prior experience and those without both in the mean final examination mark and mean assessed work scores (Table 4.5 and Table 4.6)

	Previous Prog Exp	N	Mean	Std. Deviation
Assessed Work Score	No	108	65.65	27.34
	Yes	184	77.28	23.01
Exam Score	No	108	48.64	31.92
	Yes	184	63.80	28.65
Final mark	No	108	57.14	29.06
	Yes	184	70.54	25.12

Table 4.5: Group statistics comparing students with and without prior programming experience.

		t	df	Sig. (2-tailed)
Assessed Work Score	Equal variances assumed	-3.887	290	p < 0.0001
	Equal variances not assumed	-3.717	194.764	p < 0.0001
Exam Score	Equal variances assumed	-4.184	290	p < 0.0001
	Equal variances not assumed	-4.068	205.258	p < 0.0001
Final mark	Equal variances assumed	-4.150	290	p < 0.0001
	Equal variances not assumed	-3.996	199.053	p < 0.0001

Table 4.6: Independent sample t-test comparing students with and without prior programming experience.

Post-study Questionnaire.

At the end of the course, participants who had offered to take part in the study and completed the pre-study questionnaire were approached again and asked to complete a post-study questionnaire. This was designed both to get feedback about participants' experiences of taking part in the study and to re-evaluate those factors being observed by this method, such as levels of comfort, in a repeated measures design.

81 participants completed the post-study questionnaire. To check for response bias the distribution of those who completed the post-study questionnaire was compared against the distribution of the pre-study questionnaire sample on a number of factors including age, gender, pre-study levels of comfort and their final academic score. The post-study sample was not found to be significantly different in distribution on any of these factors.

Comparison of Pre and Post Study Levels of Comfort and Gender Differences.

Of the 81 respondents 54 were male, 27 were female. The overall post-study distribution of levels of comfort expressed by both genders is shown in Figure 4.3. Significant improvements in overall level of comfort was noted on all five measures (Table 4.7), with the majority of participants indicating that they were 'very comfortable' (rated 5) on the measures of comfort in: using applications, using communications, using the internet and installing applications.

Students' levels of comfort with programming were significantly higher post-study than pre-study, but participants still indicated lower levels of comfort compared to other computing tasks.

It would be incorrect to draw the conclusion from the data that *all* students showed an improvement in their levels of comfort. It was found that in 25 cases (30.9%), participants had actually expressed lower levels of comfort on one or more measures post-study. 17 people (11 male, 6 female) expressed a lower level of comfort with programming than before, and of these most had prior programming experience. Otherwise there were no other characteristics that differentiated this group, and the group in general achieved high marks in continuous assessment (mean score = 87.69) and the final exam (mean exam mark = 76.38). Possible reasons for this finding are considered later in the Discussion.

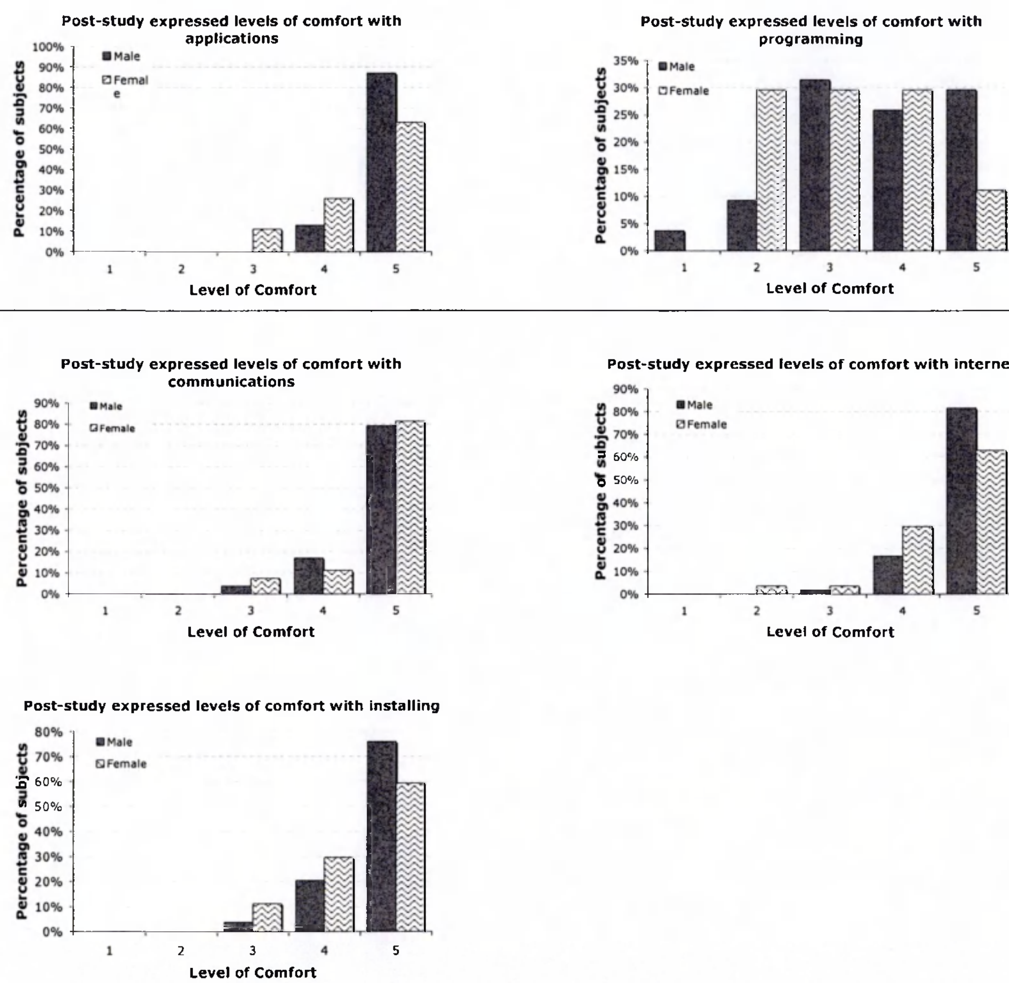


Figure 4.3: Graphs showing frequency distribution in post-study expressed levels of comfort for both sexes for various computing related tasks (N_{Male} = 54, N_{Female} = 27)

	Post-study comfort with applications	Post-study comfort with programming	Post-study comfort with internet	Post-study comfort with communications	Post-study comfort with installing
Chi Square	55.43	66.93	51.19	33.44	56.86
df	6	16	9	6	6
Sig	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$

Table 4.7: Chi Square values and significance levels comparing pre-study levels of comfort with post-study levels of comfort.

The post-study difference between males and females in levels of expressed comfort was also re-analysed (Table 4.8). Only *comfort with applications* was noted to be significantly different between the genders, although *comfort with programming* and *use of the internet* were both found to lie just outside the 5% level of significance. The general implication however is that females' levels of comfort with computing related tasks have increased and caught up with the levels of comfort expressed by males.

	Post-study comfort with applications	Post-study comfort with programming	Post-study comfort with internet	Post-study comfort with communications	Post-study comfort with installing
Mann-Whitney U	543.000	546.000	588.500	705.500	599.000
Wilcoxon W	921.000	924.000	966.500	2136.500	977.000
Z	-2.631	-1.897	-1.875	-.146	-1.630
Asymp. Sig. (2-tailed)	p = 0.009	p = 0.058	p = 0.061	p = 0.884	p = 0.103

Table 4.8: Comparison between genders of post-study levels of comfort in various computing related tasks.

It was considered whether females had started with less experience and this may have been a determining factor in level of confidence rather than gender. To test this, those respondents in the pre-study questionnaire who had indicated both prior programming experience and previous computing courses were selected. A comparison between the genders was again made on the measures of comfort used. It was found that females still indicated significantly lower levels of comfort than males with installing programs and applications (Table 4.9). There were no significant differences noted between the genders on the other measures of comfort.

The implication of this is that experience can not be precluded as a factor as females with programming and computer course experience no longer show any significant differences in levels of comfort with programming or use of the internet. The result that females with prior programming and computer course experience were still less comfortable with applications and installing than their male counterparts could be because they have had less experience in these areas.

	Pre-study comfort with applications	Pre-study comfort with programming	Pre-study comfort with internet	Pre-study comfort with communications	Pre-study comfort with installing
Mann-Whitney U	961.500	1113.500	1242.500	1152.000	979.500
Wilcoxon W	1396.500	1548.500	1677.500	1587.000	1414.500
Z	-2.576	-1.238	-.244	-1.060	-2.522
Asymp. Sig. (2-tailed)	p = 0.010	p = 0.216	p = 0.807	p = 0.289	p = 0.012

Table 4.9: Comparison between genders of pre-study expressed levels of comfort on various computing related tasks with students who have indicated both prior programming experience and computing course experience.

Pre and post-study comparison of levels of comfort between those with prior programming experience and those without.

Considering the differences in the pre-study questionnaire between those who had had prior experience of programming and those who had not, it was felt worthwhile investigating whether these differences still existed after participants had completed their studies.

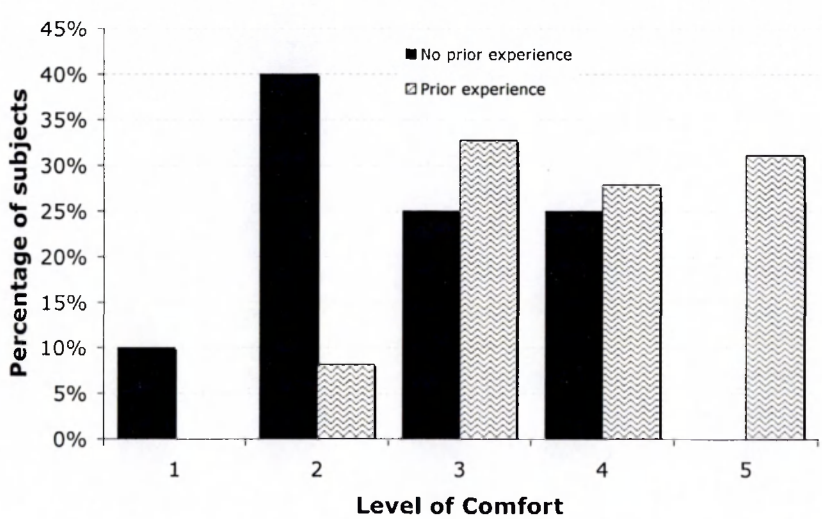


Figure 4.4: Comparison of expressed levels of comfort between those with and without prior experience of programming in post-study levels of comfort (N = 81).

As can be seen in Figure 4.4, both groups show overall increases in their expressed levels of comfort, but there is still a significant discrepancy in distribution between those with prior experience of programming and those without (($n_1 = 20$, $n_2 = 61$), $U = 262.5$, $p < 0.0001$).

Post-Study Levels of Comfort and Academic Performance.

Earlier it was found that there are small, but significant, correlations between pre-study levels of comfort with programming and measures of both examined and continually assessed academic performance. It was therefore felt worthwhile carrying out a similar analysis looking at whether similar relationships existed between post-study levels of comfort and academic performance.

Of the 81 who completed the post-study questionnaire, 3 did not take the final exam and were excluded from the analysis. Results are given in Table 4.10.

N = 78		Comfort Applications	Comfort Programming	Comfort Internet	Comfort Communications	Comfort Installation
Assessed work score	r_s	0.061	0.086	-0.019	0.192	0.040
	Sig.	p = 0.597	p = 0.453	p = 0.870	p = 0.093	p = 0.729
Exam mark	r_s	-0.212	-0.094	-0.199	0.044	-0.085
	Sig.	p = 0.062	p = 0.415	p = 0.080	p = 0.703	p = 0.460
Final mark	r_s	-0.141	-0.043	-0.130	0.107	-0.052
	Sig.	p = 0.217	p = 0.711	p = 0.258	p = 0.350	p = 0.649

Table 4.10: Correlations between post-study levels of comfort with various computing related tasks and measures of academic performance.

No significant correlations were found and it was concluded that there were no relationships between post-study levels of comfort with computing task and academic performance.

Discussion

The study shows that there are small, but significant, relationships between the level of comfort, used as a measure of self-confidence, expressed by students in undertaking computing related tasks and their performance carrying out online practical work and their eventual examination outcome. This is of particular interest as a relationship was found both with the final continuous assessment score which is directly related to students' online practical work and the examination mark which is not. Although the relationship is weak, the correlation is significant and suggests that students who express lower levels of comfort in carrying out computing related tasks at the beginning of the course could benefit from additional support designed to increase their self-confidence.

Significant differences in expressed levels of comfort were found between male and female students, with males more comfortable than females with computing related tasks. These findings are similar to previous research (Shashaani, 1994; Busch, 1995; Corston and Colman, 1996; Comber et al., 1997; Durndell et al., 2000) and anecdotal evidence that females are generally less confident with computers than males. However, it was investigated whether experience was the determining factor and females were less confident because they had less experience than males. It was found that when subjects of both sexes who had prior programming and computing course experience were compared, females were no longer significantly different from males on measures of comfort with programming and internet use, but they were significantly different on measures of comfort with applications and installing programs. This implies that experience may be a factor, but females with prior experience with programming and computer courses still may have had less experience with applications and installing than males.

Students who were less comfortable with computing related tasks were also generally slower completing LB 9. This was also found to be the case with some of the later LBs (10, 13, 14 and 15), with students' levels of comfort with programming. This suggests that, if the time a student spends actively working at an online task could be monitored automatically, those students who take longer could be identified. Although self-confidence may not be the only reason why students take longer, the evidence here shows it needs to be considered as a factor and time can be used as one indicator, so that students noted to take longer either via an adaptive system or from the tutor (if the system is allowed to give them such feedback) could be offered extra or alternative material that helps self-confidence and expertise in the subject as part of a package aimed at helping students who take longer.

An aspect brought to light by the research is the apparent persistent nature of the effect of confidence and being comfortable with carrying out a task. A relationship between Students' levels of comfort at the start of the course and their performance was seen right the way through the course, as LB 09 is typically studied in the 5th week of the course and the exams are at the end, around 35 weeks after the start. It could be postulated that this effect was being seen all the way through the course because students' levels of confidence had not changed, however this is unlikely to be the case as the post study follow-up shows significant increases in all levels of comfort in carrying out computing related tasks. In addition students' post-study levels of comfort were not found to correlate with exam performance. So why does the relationship between pre-study levels of comfort and performance still exist at the end of the course?

A partial explanation could be in another finding, that 21% of the students who completed the post-study questionnaire expressed lower levels of comfort in carrying out programming after completing the course. This would naturally affect the post-study correlation particularly as those who expressed lower levels of comfort after the course were mainly among those with prior experience of programming.

While a test-retest reliability study has not been carried out on the questionnaire (a topic for future research and discussed in Chapter 13), the evidence suggests that reliability is not the only reason even if it was found to be an issue. A small number of students (3% – 8%) do express lower levels of comfort in the other four measures and the demographic make up of this small group is representative of the demographic make up the whole sample. However, a much larger number of students express less comfort than before with programming, and 88% of these have prior programming experience.

Table 4.11 shows the pre- and post-study levels of comfort expressed and the make up by gender and prior programming experience of those who expressed lower levels of comfort with programming post-study. Analysis of the pattern of changes taking place suggest another factor other than reliability. For example, of the 8 males with prior programming experience who said they were 'comfortable' with programming at the start of the course (column 2), 7 said they were 'fairly comfortable' in the post-study follow up and 1 said they were 'uncomfortable'.

	Male				**Female**			
	Pre-study comfort with programming		*Post-study comfort with programming*		*Pre-study comfort with programming*		*Post-study comfort with programming*	
Programming Experience	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*
Level of Comfort								
Not at all comfortable	-	-	1	-	-	-	-	-
Uncomfortable	1	-	-	1	-	-	-	-
Fairly Comfortable	-	-	1	7	-	-	-	6
Comfortable	1	8	-	1	-	6	-	-
Very Comfortable	-	1	-	-	-	-	-	-

Table 4.11: Table detailing distribution of those who expressed lower levels of comfort post-study than before.

There were also no significant differences found in the final examination score between those who expressed lower levels of confidence with programming and those who stayed the same or whose confidence improved (Table 4.12 and Table 4.13)

	Post-study lower confidence in programing	N	Mean	Std. Deviation
Overall Exam Score	No	63	75.71	16.26
	Yes	17	71.88	21.41

Table 4.12: Comparison of mean Overall Exam Scores achieved between those expressing lower levels of programming confidence post-study and those who improved or stayed the same.

		t	df	Sig. (2-tailed)
Overall Exam Score	Equal variances assumed	0.804	78	p = 0.424
	Equal variances not assumed	0.687	21.235	p = 0.500

Table 4.13: Independent samples t-test of the differences between the means of those expressing lower levels of programming confidence post-study and those who improved or stayed the same.

There is no data in this research to indicate why this group students expressed they were less comfortable with programming than before. One suggestion is this could be due to a change in the programming paradigm from purely imperative (for example PASCAL) to object oriented (such as Smalltalk). It is the belief of Pete Thomas and other members of the M206 course team (Thomas, 2003) that people find it difficult to change paradigms and this may account for the negative change to be seen in this research. This view is also expressed by Budd and Pandey (1995), who argue the need to teach multiple programming paradigms and supported by Doube (2000), who found many students on a university's computing course previously learning C++ expressed anxiety and required additional support in comparison to a group who had not yet learnt a programming language, when the university switched from teaching C++ to Java. The work of Halland and Malan (2003) also looks at how prior knowledge of a programming language can help or hinder the acquisition of a new programming paradigm and comment on work by Carey and Shepherd (1988) who use the term 'transfer effects' for the negative effects of prior experience of learning a different programming paradigm.

Ideally a follow up study of this group of students should be undertaken to determine in more detail what type of programming experience they have had prior to the course. However, for those with an interest in teaching programming languages this is clearly an area for future work.

Conclusion

This study supports previous research that confidence at a task affects the performance and shows that students' expressed levels of comfort with programming at the start of a course can continue to affect their performance throughout the course and is discernable in their final examination marks. A large difference in confidence was also seen between those with and without prior experience of programming before the start of the course and this was also reflected in significant differences the marks obtained for continuous assessment and in the final examination. The implication is that students who can be identified at the start of a programming course as having a lower confidence or not having had prior programming experience may benefit from additional directed support.

In this study the measures of performance looked at were the amount of total active time taken to complete a programming exercise, assessed work and exam performance. The finding that these measures of performance can be affected by students' levels of confidence, has implications for the main body of the research as it suggests that there may be other observed behaviours and measures which although not tested here, could also be affected by the level of confidence expressed at the start.

Chapter 5.

Introduction to Learning Styles

> *"It is an extraordinary fact that if Brown and Jones both have the same need to improve an aspect of their managerial performance, and both are taken through the same learning experience, Brown will learn and Jones will not. It seems that most tutors having stumbled across this truth painfully, when an individual reacts badly to a learning process, then pick themselves up and hurry on as if nothing had happened. In designing courses the best that may occur subsequently is that the designers offer a catholic menu of activities, hoping everybody will get something out of the course. Thus the supposedly well-designed course will include role-plays, films, case studies, lectures, an afternoon in the resource centre: if you are bored by one, there is always tomorrow."*
>
> Alan Mumford (1991)

Abstract

This chapter gives an overview of the field of study in the cognitive and learning style concepts and then looks in greater detail at the styles chosen to be examined in this study.

Introduction

The comment made by Alan Mumford, quoted at the start, reflects the findings of other work, such as Robertson (1985), Zenhausern (1990) and Gordon (1998), that people exhibit significant individual differences in the cognitive processes they use to solve problems and make decisions. Interest in this area has branched into two related fields of research; *cognitive styles*, examining the cognitive processes behind our individual behaviours and perceptions, and *learning styles* which examine those processes which influence the individual ways in which we learn.

The intention of this chapter is to introduce these concepts and provide a synopsis of current understanding in the area. Those cognitive and learning styles that are of specific relevance to the present research are reviewed in greater detail.

Cognitive Styles

The construct of cognitive styles is often cited as being originally proposed by Allport (1937). Most studies in the area of cognitive styles then developed from an interest in individual differences in the 1960s and 1970s. An idea of the growth and diversity that can now be found in this field can be seen in work by Messick and associates (1976), in which 19 cognitive styles are identified and later work by Smith (1984) listing 17 different cognitive style inventories.

When discussing cognitive styles the work of Gordon Pask (Pask and Scott, 1972; Pask, 1976) also needs to be considered as his work in this field with Scott in discovering the mutually exclusive serialist/holist styles of information processing behaviour led to the development of *Conversational Theory*, that emphasises the need for the learner to 'teach-back' all that she/he has learnt and many cite as the inspiration for designing and developing learning environments and personalised information browsers (Pangaro, 2001; Scott, 2001).

There is however no comprehensive definition for the cognitive style construct. As Riding and Cheema (1991) comment,

> *"The cognitive style construct has been elusive; this is partly due to the fact that many researchers working within the learning/cognitive style research, fail to mention the existence of other types of styles. As a result...different theorists have been working with different concepts and have referred to them as a 'cognitive/learning style'."*

As well as finding the term 'cognitive style' being described under a number of different concepts, other names relating to same concepts have also been used in the literature adding to the confusion. Examples are, cognitive preferences (Tamir and Cohen, 1980) and cognitive strategies (Messick and associates [sic], 1976). Messick and associates, in an effort to distinguish between the terms cognitive styles and cognitive strategies, define cognitive styles as "high level heuristics that organise and control behaviour across a wide variety of situations" while cognitive strategies are more specific and dependent on the particular situation. However, this differentiation does not seem have been widely adopted and the term cognitive style is still used to describe those situations that Messick and associates feel more suited to be defined as cognitive strategy.

The expression *cognitive ability* is another term that occurs in the literature (Robertson, 1985; Leutner and Plass, 1998; Virvou and Tsiriga, 2000), but refers to the closely related concept of an individual's skill or capacity in a specific cognitive function or cognitive functions generally.

In general *cognitive styles* can be best thought of as referring to an individual's preferred way of perceiving, remembering, thinking and problem solving. This is a view taken by Riding and Sadler-Smith (1997) who comment that the cognitive style construct, although frequently included under the umbrella term 'learning style', is much more pervasive, stable and deep seated. They also suggest, based on an earlier extensive review of the literature (Riding and Cheema, 1991), that cognitive styles can be seen as two 'fundamental and independent dimensions', the Wholist-Analytic dimension and the Verbal-Imagery dimension. Describing the Wholist-Analytic dimension as the habitual way in which individuals organise and structure information, such that Analytics deconstruct information into its component parts, while Wholists retain a global or overall view of the information. Riding and Sadler-Smith argue that this dimension can encompass related constructs such as Pask's (1976) serialist/holist styles or correlates of it. While the Verbal-Imagery dimension represents the habitual mode of representation of information in memory during thinking, where Verbalisers consider the information they read, see or listen to in words or verbal associations while Imagers instead experience spontaneous and frequent pictorial mental pictures..

However, Riding and Sadler-Smiths's concept of the Verbal-Imagery dimension is not fully supported, as some authors perceive the visual-verbal styles as being opposite ends of a single dimension (Richardson, 1977; Felder and Soloman, 1991). Other authors present evidence that the visual and verbal styles are on separate dimensions (Kirby et al., 1988; Antonietti and Giorgetti, 1996).

There is however some question over the constancy and stability of cognitive styles. Authors such as Richardson (1977) and Zenhausern (1990) regard cognitive styles as having constant and stable characteristics, but others perceive cognitive styles to be mutable and able to shift gradually over time (Graham, 1997; Liu and Ginther, 1999). The view taken here, in common with research cited by Graham and Liu (Graham, 1997; Liu and Ginther, 1999) is that cognitive styles *can* change over time. However, the actual picture would appear to be more complicated with some styles being more mutable than others. That is, the mutability of a cognitive style is dependent on several factors including an individual's cognitive ability in the respective area and variables within the specific situation which influence how the individual chooses to process the information.

The terms *cognitive style* and *cognitive ability* are both used within this paper. Cognitive ability will refer to an individual's capacity while cognitive style will refer to the selection and actual process of using a cognitive ability.

Learning Styles

Learning styles are regarded as an extension to cognitive styles and are used to distinguish the act of learning from simple processing of information. This is the view taken by Riding and Cheema (1991) who noted that those working on learning styles took cognitive style into consideration, but were more interested in the practical, educational applications, while the term cognitive style was reserved for theoretical, academic descriptions. A further differentiation is noted by Liu and Ginther (1999) who observed that cognitive styles tend to be associated with bipolar dimensions (a single dimension with two extremes) whereas learning styles in general are usually associated with several dimensions.

A comprehensive definition for the concept of "learning styles" that has been adopted by researchers is,

> *"Composite of characteristic cognitive, affective and psychological factors that serve as relatively stable indicators of how a learner perceives, interacts with and responds to the learning environment."*
>
> Griggs (1991b)

The important points to draw from this definition is that learning styles reflect an individual's preferences and choices in a learning situation and encompass a range of factors that includes cognitive styles. An idea of the range of factors affecting a person's ability to perceive, interact and respond can be found in work by Dunn and Dunn (1978):

(a) **Environmental stimuli** (light, sound temperature, design),

(b) **Emotional stimuli** (structure, persistence, motivation, responsibility),

(c) **Sociological stimuli** (pairs, peers, adults' self, group, varied),

(d) **Physical stimuli** (perceptual strengths, including auditory, visual, tactual, kinesthetic, mobility, intake, time of day - morning versus evening, late morning, and afternoon, and

(e) **Psychological stimuli** (global/analytic, impulsive/reflective, and cerebral dominance).

However as Griggs (1991b) points out, it is important to recognise that learning styles are not related to intelligence, mental ability or actual learning performance and that no learning style can be said to be better than another. That is, the best learning style for any individual is specific to the individual and is dependent on that individual's cognitive abilities and the learning situation they are in. Put into context, a student may have a preference for visual/diagrammatic material, but in a situation where they are given a text-only book, for example, they would be forced to use the cognitive functions and style that best suits that situation, such as a verbal learning style. Alternatively, they may know of a way to process and encode the textual information that takes advantage of mental imagery techniques and so use a visual learning style. Nonetheless, it has been shown in a number of studies that the effectiveness of pedagogical material can be significantly affected by whether it matches the learning style of the individual (Griggs, 1991a; 1991b; Renniger et al., 1992; Wilson, 1996; Warren and Dziuban, 1997; Montgomery and Grout, 1998; Lang et al., 1999; Goold and Rimmer, 2000).

Assessment of Cognitive & Learning Styles

An assessment of cognitive and learning styles is important for two main reasons.

1. *To provide a reliable and valid way of being able to compare one individual against another.*

   Because a reliable test is almost unique in being reproducible and explicit (Cronbach, 1990a), we can be confident that when we compare individuals over time, we are measuring not just the same construct, but that, all things being identical, on a different occasion an individual would have the same score.

2. *Individuals are frequently unaware of their own learning style preferences and therefore are unaware of the type of learning material that is best for them.*

   For learning styles such as Witkin's Field Dependence/Indepence (Witkin et al., 1974; Witkin et al., 1977), it is unlikely that individuals would have experienced the concepts behind the style being measured. However, an individual's knowledge of their own learning style preferences could affect the type of material they select (if they have the opportunity) and those students who are not aware of their preferences may not necessarily pick the course material which is best suited to them. Lack of knowledge about learning styles by individuals could also engender feelings of inadequacy that would affect their progress. This might happen if an individual's progress is being hampered by material not meeting their learning style preferences but the person notices that others (whose learning styles match the material) are finding it much easier to learn the material. The reverse of course could be true as well.

At present the most used and convenient way to assess learning styles is through self-evaluation questionnaires - often called inventories. These provide researchers as well as educators and trainers easy, reliable and validated ways to distribute and assess individual requirements (Cronbach, 1990).

Review of questionnaires selected for use in the research project

Three questionnaires were chosen for their relevance to learning in a distance education setting and which cover a range of different cognitive concepts.

- **The Learning Style Questionnaire, Honey and Mumford** (Honey and Mumford, 1986; Mumford, 1991; Honey and Mumford, 1995)
- **Grasha-Riechmann Student Learning Styles Scales - General Class Form** (Riechmann and Grasha, 1974; Grasha, 1996b)
- **An English adaptation of the Questionnaire on Visual and Verbal Strategies** (Antonietti and Giorgetti, 1993).

The Learning Style Questionnaire, Honey and Mumford

Honey and Mumford's Learning Style Questionnaire (LSQ) (Honey and Mumford, 1986; Mumford, 1991; Honey and Mumford, 1995) is based on a simplified version of Kolb's 1984 cyclical model of the process of learning (Table 5.1) and is used to identify students' strengths and weaknesses on this model.

The questionnaire, which because of copyright is not reproduced here, was developed over a number of years after Honey & Mumford found problems with Kolb's own inventory. The LSQ comprises an 80 item self-evaluation inventory based on general behavioural tendencies rather than learning terms so that it would be usable by those not familiar with, or who had no prior knowledge of, learning style preferences. Binary choice answers (positive or negative) are employed because it was found during trials and development that this produced the same results as a five point Likert type scale (Honey and Mumford, 1995).

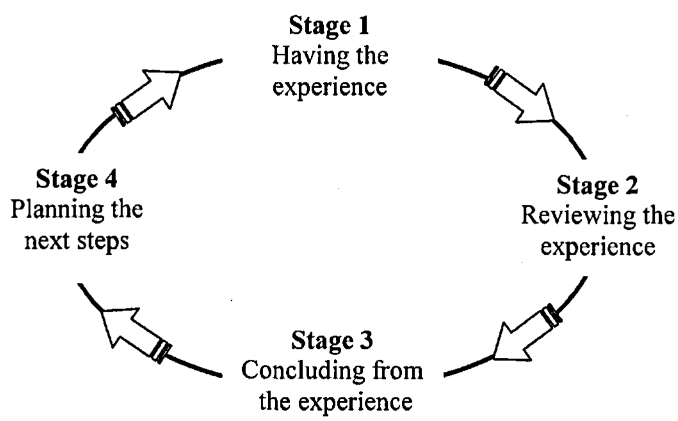


Figure 5.1: Honey & Mumford's simplified version of Kolb's 1984 cyclical model of the process of learning.

Scores obtained are ranked in relation to their percentiles according to the normative data of 3,500 people (general population) or, if desired, against normative data according to occupational group or gender. The LSQ is recognised and frequently employed within industry and business in the United Kingdom where its primary use is to help staff and training personnel identify, and take advantage of, individuals' learning style preferences on the four measures of *Activist, Reflector, Theorist* and *Pragmatist* described by the authors as "independent" of each other. Each axis or learning style is associated with one of the stages on the simplified learning cycle (Honey, 1991) and identifies an individual's strength or weakness in coping with that stage of the learning cycle. A summary of each of the associations is provided in Table 5.1.

A central assumption taken by Honey and Mumford, in line with current thinking, is that the four learning styles are dynamically capable of changing, such that an individual can improve in any styles they are weak in and become a more rounded learner. For example, someone with a strong *Activist* style (Stage 1) would learn best from new experiences and a hands-on approach, but not from passively taking part unless they also had a strong *Reflector* style (Stage 2).

Stages in the simplified Kolb's learning cycle		Associated Learning Style	
		Style	*Brief description of style.*
Stage 1	Having an experience.	Activist	What's new? I'm game for anything
Stage 2	Reviewing an experience.	Reflector	I'd like time to think about this.
Stage 3	Concluding from an experience.	Theorist	How does this relate to that?
Stage 4	Planning the next steps.	Pragmatist	How can I apply this in practice?

Table 5.1: Summary of the learning styles on Honey & Mumford's LSQ and their association with a simplified version of Kolb's learning cycle.

Grasha- Riechmann Student Learning Styles Scales - General Class Form

The Grasha-Riechmann's Student Learning Styles Scales (GRSLSS) (Riechmann and Grasha, 1974; Grasha, 1996b), is distinct in that it focuses on students' responses to actual classroom activities rather than personality or cognitive traits; identifying students' preferences for the teaching environment to help educators identify techniques that address particular learning styles. First developed in 1974 as a 90 item form it was originally based on the assumption that learning styles were describable in terms of three bipolar dimensions, *Dependent* versus *Independent*, *Participative* versus *Avoidant* and *Collaborative* versus *Competitive* (Ferrari et al., 1996). The current 60 item form no longer assumes this bipolarity and identifies the six different styles; *Independent, Avoidant*, *Collaborative*, *Dependent*, *Competitive* and *Participant* (see Table 5.2) with only the *Participant/Avoidant* types representing a clear dichotomy that is supported by statistical analysis (Montgomery and Grout, 1998).

The inventory exists in two forms: the General Class Form and the Specific Class Form. The forms differ only in the phrasing of questions, with the Specific Class Form designed for use following a specific lesson and the General Class Form phrased to look at general preferences across all classes/lessons. Both use the same general norms and are scored using a five-point Likert like scale (Tuckman, 1978; Preece et al., 2002), with the mean score for each of the six styles ranked according to its percentile position in comparison with the general norm. A scoring key identifies three levels of preference, relatively high, medium and low based on the standard deviations for the norm. The relatively high and low categories are equivalent to all scores equal to or greater than one standard-deviation from the mean. (Grasha, 2001).

Grasha-Riechmann Student Learning Styles Scales

Style	*Description of Style*
Competitive	Students who learn material in order to perform better than the others in the class. Believe they must compete with other students in a course for the rewards that are offered. Like to be the centre for attention and to receive recognition for their accomplishments in class.
Collaborative	Typical of students who feel they can learn by sharing ideas and talents. They co-operate with the teacher and like to work with others.
Avoidant	Not enthusiastic about learning content and attending class. Do not participate with students and teachers in classroom. They are uninterested and overwhelmed by what goes on in class.
Participant	Good citizens in class. Enjoy going to class and take part in as much of the course activities as possible. Typically eager to do as much of the required and optional course requirements as they can.
Dependent	Show little intellectual curiosity and learn only what is required. View teacher and peers as sources of structure and support and look to authority figures for specific guidelines on what to do.
Independent	Students who like to think for themselves and are confident in the their learning abilities. Prefer to learn the content that they feel is important and would prefer to work alone on course projects than with other students.

Table 5.2: Grasha & Riechmann's Student Learning Styles (Grasha, 1996b)

Montgomery and Grout's (1998) review of studies using the Grasha-Riechmann Student Learning Styles found that women students typically have higher scores on the collaborative style and that students over 25 years of age tend to employ more independent and participatory styles.

However Ferrari et al. (1996) in their study of the GRSLSS, examining the factor structure and other psychometric features of the 60 item inventory, found it had the same shortcomings as the 90 item inventory and did not yield a clear, stable, factor structure that addressed the underlying theory of what it was supposed to be measuring. Nevertheless, Grasha reports that Cronbach's alpha, a model of internal consistency, based on the average inter-item correlation (*SPSS for Windows,* 2002), for each scale of the six styles measured range from 0.68 to 0.75 across the samples and that there is a modal alpha of 0.72 for the entire test (Grasha, 2001). It has therefore been taken that the GRSLSS is usable.

Visual and verbal styles

The LearningBooks used by students on the M206 course present the information in both visual and verbal formats. Therefore, a questionnaire was sought that measures the visual and verbal preferences of students taking part in the study.

There are however differences between tests which measure the visual/verbal cognitive style and those that measure visual/verbal learning styles. In a review of tests measuring the visual and verbal styles, Leutner and Plass (1998) report that tests of visual/verbal cognitive abilities were useful for predicting students' learning outcomes, but tests of visual/verbal learning styles were less successful in predicting learning outcomes. Leutner and Plass comment that the difference is possibly due to the type of test material being used, as tests measuring cognitive ability are based on behavioural observation whereas tests of learning style have relied on self-reported questionnaires. Current evidence also indicates that most people can switch between verbal and visual strategies according to the nature of the task, although some people appear to be heavily dependent upon one or other of the strategies according to cognitive ability (Richardson, 1977; Baddeley, 1987; 1990; 1992; Antonietti and Baldo, 1994; Antonietti and Colombo, 1997; Lang et al., 1999).

Visual Verbal Questionnaire (VVQ)

Richardson's Visual Verbal Questionnaire (VVQ) (Richardson, 1977) is an instrument that provides a measure of individuals' reliance on visual or verbal modes of thinking. The majority of studies that have been performed with it, however, are research studies investigating its validity and reliability rather than actually using it to investigate an individual's visual/verbal preferences (Riding and Cheema, 1991).

Richardson developed the VVQ following a perceived need to produce better methods of measuring 'vividness of memory images'. He had found that despite conceptual and empirical differences between Paivio's (1971a) "Ways of Thinking questionnaire", which Paivio later calls the "Individual Differences Questionnaire" (1983), and the revised Bett's questionnaire (Sheehan, 1967), both questionnaires had similar factors/attributes in the imagery measure based on an individual's ability to form mental images. However both the revised Bett's and the Ways of Thinking Questionnaire's scores could be influenced by one of three response sets. Of these, the Ways of Thinking questionnaire was found to be less susceptible to this source of bias and on this basis Richardson considered creating a subset of questions.

The inventory consists of 15 items which users mark as true or false. However, the VVQ is scored on the assumption that visual and verbal attributes are at opposite ends of a bipolar scale, which is not supported by research (Kirby et al., 1988; Antonietti and Giorgetti, 1996). There are many other criticisms of the questionnaire reported in the literature stating poor reliability, poor item discrimination, and a high degree of bias in answers (Antonietti and Giorgetti, 1992; 1996; 1998; Leutner and Plass, 1998). For this reason an alternative questionnaire was sought.

Questionnaire on Visual and Verbal Strategies (QSVV)

Antonietti and Giorgetti's (1993) "Questionnaire sulle Strategie Visive e Verbali" (QSVV) (Questionnaire of Visual and Verbal Strategies) was chosen as an alternative to the VVQ. Like the VVQ it is short consisting of only 18 items, marked on a 5 point Likert-like scale, but measures visual and verbal cognitive styles on separate scales. The use of QSVV is however not without potential problems as it was written in Italian and all validity and reliability studies were carried out on Italian subjects. An English translation of the questionnaire was obtained for use in this study. Chapter 8 details the validity studies carried out on the English version and the normative data for a population of distance education students.

Witkin's Field Dependence – Field Independence style

Another learning style considered was Witkin's Field Dependence – Field Independence style (Witkin et al., 1974; Witkin et al., 1977). This style was developed from the finding that some individuals, when their bodies were tilted in space and placed in a room at the same orientation, reported that they were in a normal position, while others "regardless of the position of the surrounding room, bring the body more or less to the upright. They seem able to apprehend the body as entity discrete from the surrounding field,". The style effectively defines how well individuals can distinguish parts of a field discretely from the whole or surrounding field, such that Field Independent individuals are better at perceiving part of a field independently of the whole field.

The Field Dependent – Field Independent style is of interest because Field Independent individuals as well as being more analytic may be better with object oriented languages because of their ability to perceive parts of the field discretely from the whole and so perceive the individual components of the program better than those who are Field Dependent.

The Field Dependent – Field Independent style is currently being investigated by other researchers (Liu and Reed, 1994; Hall, 2000; Chen and Macredie, 2002; Parkinson and Redmond, 2002; Redmond et al., 2003). However, it was felt its inclusion in the current study at the present time in addition to the three questionnaires already selected would encumber participants too much and possibly put them off taking part in the study.

Chapter 6.

Normative Data Study of Distance Education Students

"Obtaining subjects is like betting on a horse. The most realistic assumption to make is that your expectations will turn out to be wrong."
Ray Hodgson and Stephen Rollnick (1989), p 4

Abstract

The responses from a sample of 181 distance education students taking courses at the Open University were collected for the Honey and Mumford Learning Styles Questionnaire and the Grasha-Riechmann Student Learning Style Scales. The sample was found to be representative of the age ranges and courses being taken by the Open University distance education student population and normative data for this population were developed. The distance education students were found to be significantly different in distribution to published norms for the general public on most learning styles. Findings are discussed and some conclusions are drawn.

Introduction

In any measure, such as a psychometric test, an individual's score has little value unless it can be compared against other scores (Cronbach, 1990, p125). When an individual's measure or a group of individuals' measures needs to be evaluated against the performance of others outside of the group, it is necessary to compare them against the norms compiled for clearly defined populations (Cronbach, 1990).

A study carried out by Logan and Thomas (2002b) looked at the learning style preferences of a group of distance education students who are learning to program. Three different measures of learning style were used: Honey and Mumford's Learning Styles Questionnaire (Honey and Mumford, 1986) (LSQ), Grasha and Riechmann's

Student Learning Styles Scales - General Class Form (Grasha, 1996b) (GRSLSS) and an English translation of Antonietti and Giorgetti's (1993) Questionnaire on Visual and Verbal Styles ($QSVV_{Eng}$). For the LSQ and GRSLSS, individuals' raw scores are normalised using norms based on a sample of the general population as their reference group. The LSQ in addition gives more specific norms for sub-populations which include different types of management, salespersons, as well as cultural comparison norms for United States of America, Australia and Greece (Honey and Mumford, 1995). The QSVV, developed originally in Italy, has norms for an Italian general population, but there are, as yet, no norms for the English version ($QSVV_{Eng}$).

In order to provide a more meaningful comparison group for the students studying M206 in the Logan and Thomas study, normative data for the population of Open University distance education students was sought as these students will have more in common with particular significance to the learning style questionnaires used. Factors such as choosing to work from home rather than studying with others in a classroom may distinguish Open University students from the population at large, for example.

The following subsection outlines the procedure used to obtain a normative sample of Open University students.

Method

The same three questionnaires used in the Logan and Thomas (2002b) study were used to gather normative data.

The three learning style questionnaires were made available for answering online via a webpage along with an additional questionnaire used in the previous study, the Computing General Demographic Questionnaire (CGDQ) (Logan and Paine, 2000). This questionnaire collected standard demographic data and responses to questions pertaining to a subject's use and comfort with information technology. As well as gaining desired demographic data the use of the CGDQ also made the conditions under which data was gathered comparable to the original presentation in the Logan and Thomas study, as the addition or exclusion of the CGDQ could affect the way some participants answered the other questionnaires.

To comply with stipulations made by the publishers of the Learning Styles Questionnaire (used with permission), the questionnaires were password-protected and made only accessible to those taking part.

Sample Selection

Some learning styles change over the course of time (Graham, 1997; Liu and Ginther, 1999), particularly those in the Learning Style Questionnaire (Honey and Mumford, 1986), which are expected by the authors to be influenced by the amount of practice a student gets in that style of learning. Therefore it was decided to select only those students who were at a comparable academic level to the original study, that is, those taking second level courses.

Subjects were selected by the Open University's Survey Office from across the range of courses offered by all academic units in the University (known as Central Academic Units or CAUs) based on the criteria of whether students had given an email addresses for contact purposes, that they were taking a second level course and that they were not already involved in another experimental project being carried out by the university.

It is useful to note at this point that at the Open University a 'course' is a unit of study or module in a modular degree structure. Students can select from a range of courses across the whole academic curriculum of the university. An individual course is presented by a particular academic unit (Faculty, School, etc.)

Sample Size

The larger the sample size the more representative it will be of the population being measured (Cronbach, 1990). However, a restriction imposed by the publishers of the Learning Styles Questionnaire to allow the questionnaire to be used freely restricted the sample size to 200. To keep within this restriction and to be flexible enough to allow larger sample sizes for the other questionnaires to be obtained, it was decided that when a total sample size of 200 had been achieved, the web page would be republished but without the Learning Styles Questionnaire.

Based on estimated previous return rates of 35-40% reported by the Survey Department in the Open University using similar email survey techniques (Prince, 2003), and taking into account that some email addresses may be invalid, 1000 students from different subject areas were selected at random from a database using the criteria mentioned earlier.

For ease of handling and to enable the protection of individuals' privacy, all email addresses were managed as a central email list to which only the list administrator could post.

Study scheduling

The dynamic nature of some of the learning styles being measured meant the timing of the data collection also had to be taken into consideration. It was initially proposed to collect data from students at the start of their courses in February 2002 as this would provide a sample that looked at students prior to the start of their second level courses. A series of unforeseen circumstances meant that a student sample was not obtained until July, 2002. However, this had its advantages as we can be certain that all students participating in the survey at this point had completed a significant proportion of at least one distance education course and were all at a minimal level of experience. It is possible at the Open University for a student new to distance education to take a second level course directly.

Students were contacted by email in June, 2002, explaining the nature of the study and invited to take part. Those wishing to do so were directed by hyperlink to the questionnaires.

Results

Response Rate

912 of the 1000 students contacted had valid email addresses. Of those contacted, 186 responses had been collected by the end of July. However, 36 (19.55%) were duplicate entries mostly where an individual had submitted an incomplete set of questionnaires shortly followed by a fully completed set of questionnaires. 6 other responses only had student identification, but no other questions answered. This left an effective response rate of 15.7%, much lower than expected for email survey return rates for the Open University (Prince, 2003) and for mail based surveys (Kanuk and Berenson, 1975). In order to improve on the original response rate, a second, follow up, email was sent out early in August to the original subject sample. This slightly improved the total response rate to 232. However, of the 46 new responses, 12 were duplicate entries and 2 others had no data giving an effective final response rate of 19.7% (Table 6.1).

A small proportion of respondents did not complete all the questions in the questionnaires or left a section out. These were left out on a case by case basis if the information relevant to a calculation was missing.

	Total Responses	Duplicate Entries	Identification only, No Data	Total available for analysis	Valid Response Rate
July 2002	186	36	6	144	15.7%
August 2002 (includes July total)	232	44	8	180	19.7%

Table 6.1: Table showing response rates to online survey.

Data Demographics

Age

Participants were asked in the CGDQ to give an indication of their age by selecting an appropriate age range. A detailed breakdown of age range by gender is given in Table 6.2. The median for females was 36-40 and for males 41-45. The difference in distribution of ages between genders was found to be significant (χ^2 = 22.31, 9 df, p = 0.0079).

Age Range	Male	Female	Total
Under 20	0	0	0
21-25	3	9	12
26-30	9	13	22
31-35	20	14	34
36-40	9	11	20
41-45	19	16	35
46-50	5	18	23
51-55	7	10	17
56-60	7	1	8
61-65	1	1	2
Over 65	5	0	5
Missing			2
Total number	85	93	180

Table 6.2: Table showing frequency count of age by gender.

Courses being taken.

To determine whether or not the sample of students was a representative cross section of the second level courses being taken at the Open University, information on what course units students were taking was requested. For this students were given a text form field, allowing free response. Most students typed in the course code/s, but a few gave the title only. Responses to this question were recoded by hand into several variables including how many courses each student was taking and the central academic unit responsible for the course.

Most students in the study sample (83.8%) indicated that they were taking only one course, although a sizable proportion (16.2%) were taking two or more courses. Of these the majority were studying precisely two courses (Table 6.3). This is to be expected as each course carries a number of points (reflecting the amount of work involved) and students are only allowed to study for a maximum 120 points over a 12 month period.

Number of courses/individual	Frequency count	Frequency Valid %
1	145	83.8
2	25	14.5
3	2	1.2
4	1	0.6
Missing	7	
Total	173	100.0

Table 6.3: Number of courses being studied by individuals

In order to assess how representative the sample was of the total population of students taking second level courses in the Open University, a frequency distribution table was drawn up of courses being taken by CAU against the actual head count of students taking second level courses by CAU (Table 6.4). The latter information comes from the Open University's Planning Office Statistical Services. These findings are represented graphically in Figure 6.1.

The sample distribution was not found to be statistically different from the known distribution of Open University students taking second level courses ($\chi^2 = 13.81$, 8 df, $p = 0.0868$); with the exception of the sample studying second level courses presented by the Health and Social Welfare academic unit (HSW) which were found to be significantly smaller than expected ($\chi^2 = 7.53$, 1 df, $p = 0.006$). The implication is that although the sample appears to be representative of the actual total Open University population of students taking second level courses overall, it may not fully represent the proportion of students who are studying Health and Social Welfare courses.

Central Academic Unit	Frequency Count in Sample	% of Sample Total	% of All Open University Students Taking Second Level Courses
Arts	25	15.4%	16.2%
OUBS	5	3.1%	3.0%
Social Sci.	17	10.5%	14.4%
FELS (Edu)	18	11.1%	9.9%
FELS (Lang)	8	4.9%	3.2%
HSW	4	2.5%	8.9%
Maths & Computing	34	21.0%	17.1%
Science	27	16.7%	15.2%
Technology	24	14.8%	12.0%
Total	162	100.0%	100.0%

Table 6.4: Frequency distribution of subject sample by faculty code.

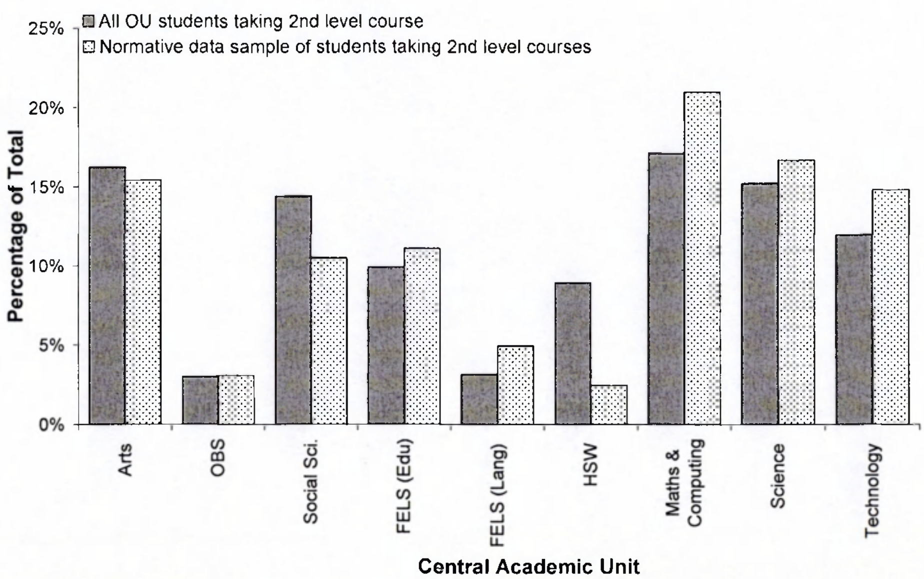


Figure 6.1: Comparison by Central Academic Unit of distribution of student sample taking second level courses against known total student population taking second level courses.

Interdisciplinary Comparison

The small sample size in some of the individual CAUs makes it difficult to create a useful normative data sample for each of the academic units and therefore to have comparisons of learning styles between the types of students who take the courses by

CAU. Nevertheless, it is common practice by the university to divide the CAUs by subject into Arts and Science based areas. Science consists of the Maths & Computing, Science and Technology CAUs, while all the other CAUs come under Arts. Some students indicated that they were doing both science and arts based courses so individuals were therefore divided into one of three groups depending on whether they were taking only science courses, only art courses or taking both science and arts courses (Table 6.5).

The number of students taking arts or science courses allowed us to compare these two groups, but the number of students who indicated they were taking both science and arts courses was very small and therefore makes it difficult to carry out any statistical comparison using this group.

Course	Frequency	%
Art	85	49.4
Science	83	48.3
Science & Art	4	2.3
Total	172	100.0

Table 6.5: Frequency table of subjects taking Science or Art based subjects.

Art Versus Science Comparisons

It is commonly reported in the literature that there is a gender bias between arts and science based subjects (Schulenberg et al., 1991; Colley et al., 1994; Stumpf and Stanley, 1998), with females showing a preference for arts based subjects and males having a preference for science based subjects. This was explored in the sample as well as looking at age as a factor.

A highly significant difference was found between the distribution of males and females in the arts and sciences with males, as expected, being more predominant in the sciences while females were more predominant in the arts (χ^2 = 12.93, 1 df, p = 0.0003) (Table 6.6).

	Art	Science	Total
Male	29	52	*81*
Female	57	33	*90*
Total	*86*	*85*	*171*

Table 6.6: Distribution of subjects by genders in the arts and sciences.

The implications of this gender bias are covered in the Discussion section later.

The analysis of the data relating to the age distributions between genders in science and arts showed no significant differences.

Comparison of distance education students with published normalised scores

To determine how comparable the obtained sample was to published norms, the frequency distribution of scores obtained from the Open University distance education sample was compared against the published normalised scores for the Honey and Mumford Learning Style Questionnaire and the Grasha-Riechmann Student Learning Style Scales.

Learning Style Questionnaire, Honey & Mumford.

The frequency distribution for the Open University student sample is given in Table 6.7 along with a statistical comparison using a Chi Square goodness-of-fit analysis against published norms. The student sample was noted have a significantly stronger preference than the general population for the Activist, Reflector and Theorist learning styles, but were not significantly different on the Pragmatist style. This is shown in graphical format in Figure 6.2.

	Activist	Reflector	Theorist	Pragmatist
N=	177	177	177	177
Very low preference	2.82%	8.47%	11.86%	9.60%
Low preference	18.64%	13.56%	19.77%	22.60%
Moderate preference	40.11%	22.60%	25.42%	36.16%
Strong preference	13.56%	32.20%	23.73%	24.86%
Very strong preference	24.86%	23.16%	19.21%	6.78%
Difference from expected				
χ^2 (df=4)	*50.52*	*60.71*	*25.64*	*5.77*
Sig	*p<0.001*	*p<0.001*	*p<0.001*	*p= 0.2169*

Table 6.7: Frequency distribution in the Learning Styles Questionnaire by Open University students and results of statistical comparison with published norms.

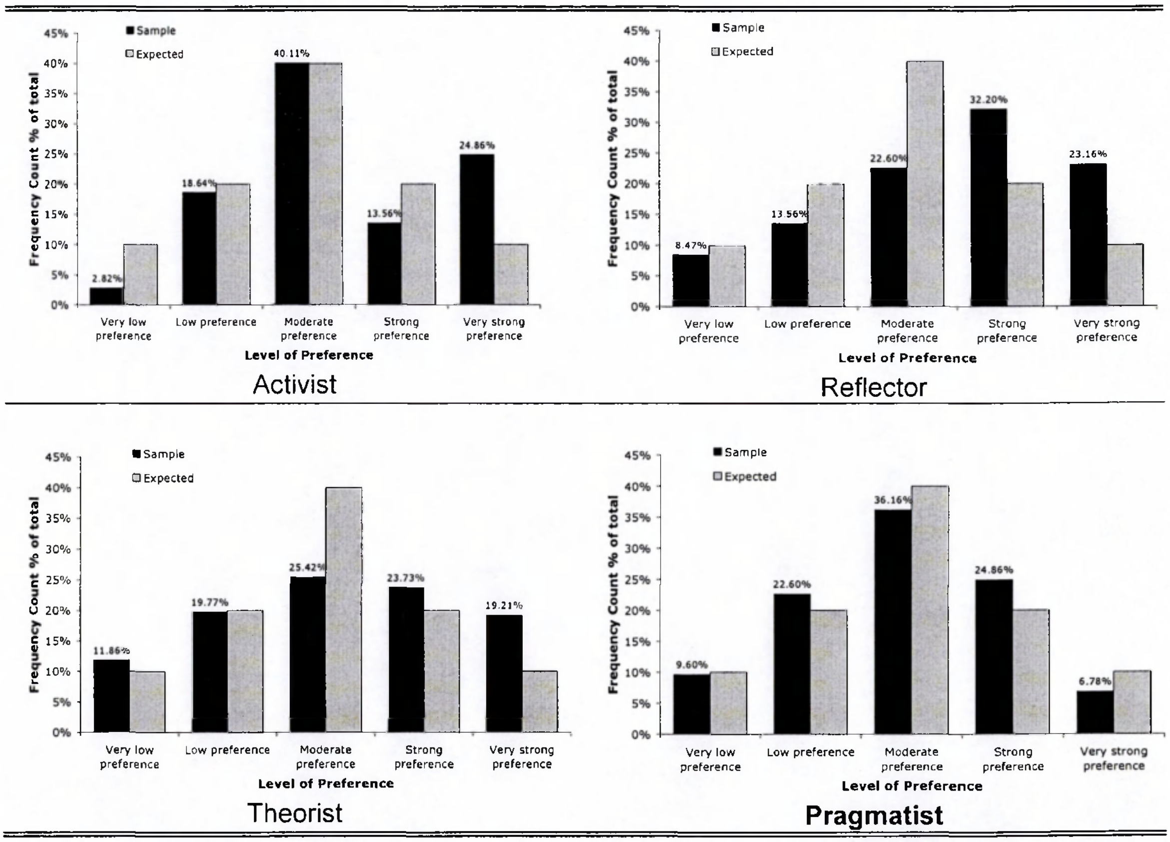


Figure 6.2: Comparison of distance education student sample on the Honey & Mumford Learning Styles against published norms for general population.

As Honey and Mumford (1995) gave sets of norms for both genders it was possible to use this to convert raw scores to their gender respective norms and compare the frequency distribution in the learning styles between the genders. These are shown in Figure 6.3.

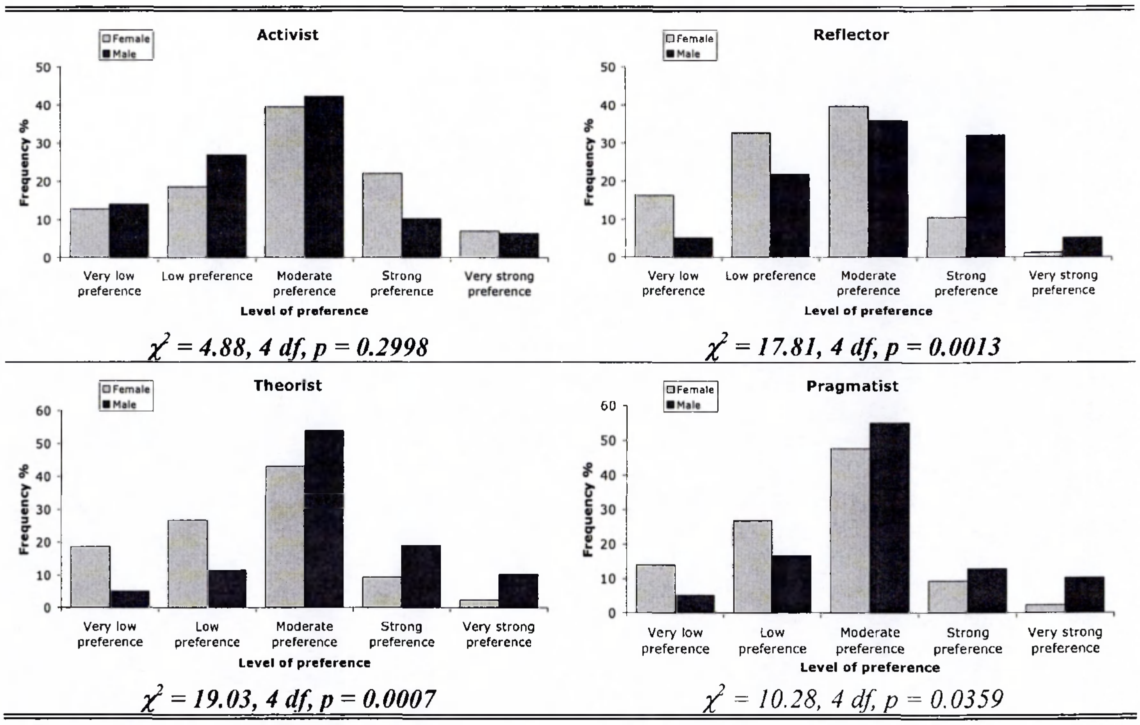


Figure 6.3: Frequency distribution for a sample of Open University distance education students comparing genders on the Honey and Mumford Learning Styles Questionnaire with Chi square analysis values.

Data for 91 females and 84 males were compared. There was no significant difference found in the frequency distribution between the genders on the Activist learning style ($\chi^2 = 4.88$, 4 df, $p = 0.2998$), but significant differences between the genders were found on the other three styles. Reflector ($\chi^2 = 17.81$, 4 df, $p = 0.0013$), Theorist ($\chi^2 = 19.03$, 4 df, $p = 0.0007$) and Pragmatist ($\chi^2 = 10.28$, 4 df, $p = 0.0359$). In all three styles males show a higher preference for the style than females. This is a similar finding to the difference in the norms stated by Honey and Mumford (1995), where males were also noted to have a greater preference for the styles than females, but this was not so significant as with the Open University student population.

Grasha-Riechmann Student Learning Styles Scales

The 5 learning styles selected from the Grasha Riechmann Student Learning Styles Scales (See Chapter 5) were similarly compared to expected distributions. Grasha, in personal correspondence (Grasha, A. F., 2001, (Appendix C)), comments "The goal was to get scores that put approximately 20-25 percent of the sample approximately 1SD below and 20-25% - approximately 1SD above the mean." However, a standard deviation in a normal distribution by definition encompasses about 68% of the sample population around the mean (Lane, 2001). Therefore, in percentile terms one standard deviation either side of the mean are at the 16^{th} and 84^{th} percentiles, not the 20^{th}-25^{th} or 75^{th}-80^{th} percentiles mentioned by Grasha.

Calculations based on Grasha's stated figures of 25% and 75% are detailed later. However, for the purposes of comparing the Open University student sample against published norms, it has been assumed that the published normal scores for the general population are based on high and low preference values being a defined 1 standard deviation above and below the mean. That is, 16% of the population having a low preference, 68% of the population having a moderate preference and 16% of the population having a high preference.

The frequency distribution for the Open University student sample in the GRSLSS is given in Table 6.8 along with the results of a statistical comparison using a Chi Square goodness-of-fit analysis against expected values (Grasha, 1996b), where it has been assumed from Grasha's description that the upper and lower limits are one standard deviation from the mean.

Because Grasha also mentions trying to get lower and upper limits to include 20-25% of the population respectively, it would be interesting to see whether the significant differences found between the Open University student sample and general population norms also exist at these levels. A repeat of the Chi Square goodness-of-fit analyses were carried out using 25% as the expected frequencies in the upper and lower preference groups as opposed to 16%. The distribution of the Open University sample was still found to be significantly different.

Preference	Avoidant	Collaborative	Dependent	Independent	Participant
N=	177	177	177	177	175
Low	8.5%	13.8%	23.7%	5.1%	9.1%
Moderate	73.4%	30.5%	69.5%	61.6%	68.6%
High	18.1%	55.9%	6.8%	33.3%	22.3%
Difference from expected					
χ^2 *(df=2)*	*7.44*	*216.91*	*16.22*	*48.22*	*9.46*
Sig	*p=0.0242*	*p<0.0001*	*p=0.0003*	*p<0.0001*	*p<0.0088*

Table 6.8: Frequency distribution in the Grasha and Riechmann Student Learning Styles Scales by Open University students and statistical comparison with expected frequencies.

The frequency distribution of the Open University sample on the GRSLSS is presented graphically in Figure 6.4, in comparison with expected values for one standard deviation above and below the mean.

Examination of the frequency distribution in the individual Grasha-Riechmann learning styles shows that, in comparison with the published norms, the sample of distance education students at the Open University have a greater preference for Collaborative and Independent learning than the general population. Conversely, they also have less preference for a Dependent learning style. The Avoidant and Participant learning styles are also noted to be significantly different from the expected distributions, with the Open University sample again showing a higher preference for these styles than the general population.

As differences between the genders were found on the Learning Styles Questionnaire, a comparison of the frequency distributions between the genders on the Grasha-Riechmann Student Learning Style Scales was also carried out using a Chi Square analysis, but no significant differences were found between the genders (Table 6.9).

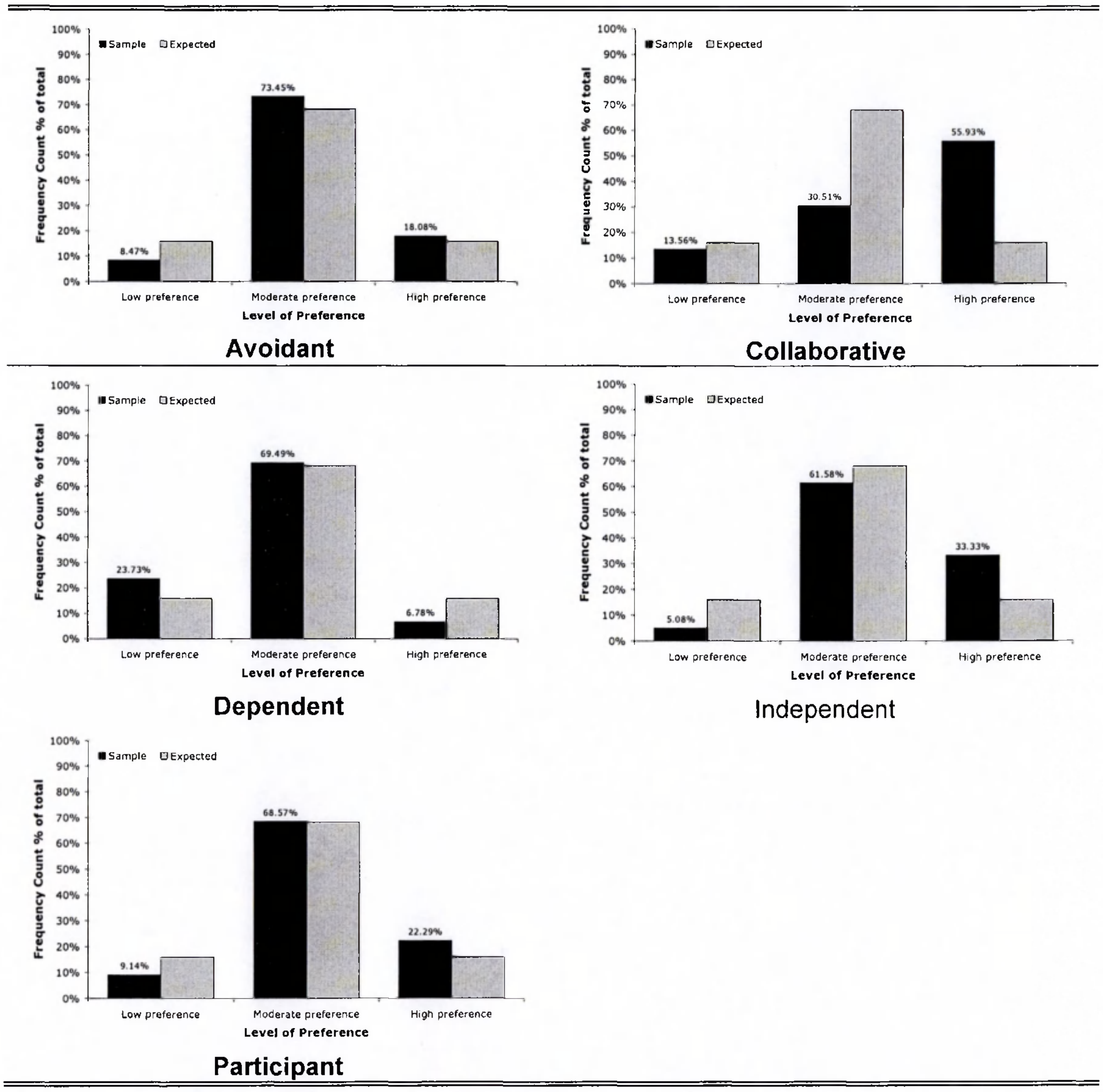


Figure 6.4: Comparison of distance education student sample on the Grasha-Riechmann Student Learning Style Scales against published norms for general population

	Avoidant	Collaborative	Dependent	Independent	Participant
χ^2 (df=2)	3.436	5.155	5.073	2.667	1.582
Probability	p=0.1794	p=0.0759	p=0.0791	p=0.2635	p=0.4533

Table 6.9: Results of Chi Square analyses between genders on Grasha-Riechmann Student Learning Styles Scales.

Conclusions that can be drawn from this are covered in the discussion.

Development of normal scores for distance education students

The Logan and Thomas (2002b) study found significant differences in the distribution of learning style preferences between M206 computing students and the general population. This raises the question of why there are differences and whether the differences observed are because the students are distance education students or because of something more specific such as being computing students. To answer this question we needed to develop a set of normalised scores for an equivalent group of distance education students from across all the subject areas available at the Open University so that a comparison could be carried out. The normative data obtained from the distance education sample will also be of use to anyone else wishing to compare their data against a sample of distance education students.

The sample of Open University distance education students taking a second level course was found to be representative of the total sub-population of distance education students at the Open University.

The norms for the Learning Styles Questionnaire and the Grasha-Riechmann Student Learning Styles Scales were calculated according to standard methodology (Cronbach, 1990) and using the percentile cut-off points defined by each questionnaire.

Learning Style Questionnaire, Honey & Mumford (1995)

The Learning Style Questionnaire uses 5 levels of preference each based on a relative proportion of the population (Table 6.10).

Based on the percentile cut-off points for each band of preference as set out in Table 6.10, the norms for the Open University student sub-population are calculated and presented in Table 6.11.

Band	Preference	Percentile range
Band A	Very strong preference	90-100
Band B	Strong preference	70-90
Band C	Moderate preference	30-70
Band D	Low preference	10-30
Band E	Very low preference	0-10

Table 6.10: Honey & Mumford Learning Style Questionnaire, Levels of preference and respective percentile cut-off points.

ALL	Very Low Preference	Low Preference	Moderate Preference	Strong Preference	Very Strong Preference
Activist	0 – 5	6 - 8	9 – 12	13 – 15	16 – 20
Reflector	0 – 9	10 – 13	14 – 17	18 – 19	20
Theorist	0 – 7	8 – 10	11 – 15	16 – 17	18 – 20
Pragmatist	0 – 9	10 – 11	12 – 15	16	17 – 20

Table 6.11: Learning Style Questionnaire Scoring Norms for Open University Distance Education Students Sub-population.

Because of the significant difference between the genders, a separate set of norms for each gender were also developed. These are given in Table 6.12 and Table 6.13.

FEMALE	Very Low Preference	Low Preference	Moderate Preference	Strong Preference	Very Strong Preference
Activist	0 – 5	6 – 8	9 – 13	14 – 15	16 – 20
Reflector	0 – 8	9 – 12	13 – 16	17 – 18	19 – 20
Theorist	0 – 5	6 – 9	10 – 13	14 – 16	17 – 20
Pragmatist	0 – 8	9 – 10	11 – 14	15 - 16	17 – 20

Table 6.12: Learning Style Questionnaire Scoring Norms for the Sub-population of Female Distance Education Students at the Open University

MALE	Very Low Preference	Low Preference	Moderate Preference	Strong Preference	Very Strong Preference
Activist	0 – 5	6 - 7	8 – 11	12 – 14	15 – 20
Reflector	0 – 11	12 – 14	15 – 18	19	20
Theorist	0 – 9	10 – 12	13 – 15	16 – 18	19 – 20
Pragmatist	0 – 10	11 – 12	13 – 15	16 – 17	18 – 20

Table 6.13: Learning Style Questionnaire Scoring Norms for the Sub-population of Male Distance Education Students at the Open University

Grasha-Riechmann Student Learning Styles Scales

Grasha and Riechmann set out three levels of preference. It is assumed here from Grasha's personal communication (Grasha, 14th September 2001) that the category of "Moderate Preference" encompasses the proportion of the population who are within 1 standard deviation from the mean. Based on this the norms for the Open University student sub-population are calculated and presented in Table 6.14.

	Low Preference (below 1SD)	Moderate Preference (within 1SD)	Strong Preference (above 1 SD)
Independent	1.0 – 3.2	3.3 – 4.1	4.2 – 5.0
Avoidant	1.0 – 2.0	2.1 – 3.2	3.3 – 5.0
Collaborative	1.0 – 2.8	2.9 – 4.3	4.4 – 5.0
Dependent	1.0 – 2.8	2.9 – 3.8	3.9 – 5.0
Participant	1.0 – 3.2	3.3 – 4.3	4.4 – 5.0

Table 6.14 Grasha Riechmann Student Learning Styles Scales Norms for Open University Distance Education Students.

Discussion

Multiple submissions

There were a number of respondents who submitted (inserting a database entry) their responses to the questionnaire several times. On analysis:

- 25 subjects (10.7%) submitted after completion of the first field only, then re-submitted at a later time with all fields of the questionnaire completed fully.
- 3 subjects (1.3%) submitted part way through completion of the questionnaire before continuing to complete it fully and submitting again.
- 11 other subjects (4.7%) submitted their fully completed questionnaires twice.

The probable reason for this behaviour can be found by examining the HTML code of the online combined questionnaire (Figure 6.5) and its behaviour when viewed in internet browsers such as Internet Explorer (*Microsoft® Internet Explorer*) and Netscape (*Netscape Navigator*) shows that when the enter key is pressed after a text or radio type input has been selected the software submits the form's data just as though the submit button had been pressed.

```
<p align="center">
<input type="submit" name="Submit" value="Submit">
<input type="reset" name="Clear" value="Clear">
</p>
</form>
```

Figure 6.5 Portion of HTML code in combined questionnaire showing input type buttons.

It is hypothesised that subjects who submitted a partially completed questionnaire and then carried on to submit completed questionnaires, had the expectation that pressing the enter key would navigate them to the next data entry field, not that it would carry out the 'submit' command. Support for this comes from observation of the behaviour the enter key in common programs where users may have had prior experience of entering data into fields such as spreadsheets, for example Excel (*Microsoft® Excel 2002*), and databases, for example Access (*Microsoft® Access 2002*), where the enter key is programmed to behave as a navigational key and move to the next field after completing entry of an individual data cell.

An additional 6 subjects sent in a submission with only the first field (user identification) completed, but did not go on to submit anything else. It is hypothesised that in these cases the respondents instead of then going on to complete the questionnaire, gave up.

It is unclear why 11 subjects submitted fully completed questionnaires twice. A working but totally unsubstantiated hypothesis is that they received no screen confirming the submission of their data. This would happen if they completed and submitted the questionnaires while disconnected from the internet.

Considering the number of subjects (17%) who sent in multiple submissions, it appears that this is a worthwhile area for future investigation of user interface design. A simple study would be to look at users who are both familiar and not familiar with completing online forms, about what their expectations are of the behaviour of the enter key.

Sample Representativeness

The sample of distance education students obtained from the Open University is relatively small in comparison to the total Open University student population (over 200,000). The sample however does have the same proportions as the total student population with regard to age and types of courses being taken.

The only academic unit that is not so well represented by the sample is that of the School of Health and Social Welfare where the number of responses from students taking courses presented by this CAU are under-represented (2.5% of total as opposed to 8.9%). A possible explanation lies in the original selection mechanism of students, as a criteria set by the Open University's research ethics committee was that students selected should not already be taking part in another study. This has particular relevance to the School of Health and Social Welfare which undertakes a number of research studies involving Open University students. This is supported on subsequent examination of the subjects selected to be contacted, where is was found that subjects taking courses presented by the School of Health and Social Welfare were under-represented (4.2% of total population).

Although this particular sub-group of students were under-represented, given the small size of the School of Health and Social Welfare unit in the Open University (8.9% of total number of Open University students) it is not felt that this unduly affects the overall composition of the sample, and the sample obtained therefore reflects the total Open University distance education student population studying second level courses.

Arts and Science Gender bias

Studies by Schulenberg et al. (1991), Colley et al (1994) and Stumpf and Stanley (1998) looking at students in colleges and secondary schools all report finding a gender bias between the arts and sciences. Although the Open University student population is more mature, on average in their thirties, the same gender bias has been found.

It would be interesting to examine the causes of this as it would help determine the effectiveness of initiatives taken by the government to encourage more women into science (*The Rising Tide*, 1994). A possibility is that the subject gender bias seen in the current Open University student population is a reflection of older stereotypical expectations that were there before government initiatives were introduced to promote female school and college students into the sciences (there is no equivalent initiative to promote males into the arts). However this does not preclude other, possibly more important, factors such as cognitive differences between the genders resulting in the gender bias.

Comparison of distance education students with published normalised scores

The sample of Open University distance education students obtained were found to have on the subscales of the Honey & Mumford Learning Styles Questionnaire and the Grasha-Riechmann Student Learning Styles Scales a significantly different distribution to the published norms for the scales.

Honey & Mumford Learning Styles Questionnaire

In the Honey & Mumford Learning Styles Questionnaire the distance education sample had significantly higher preference for the Activist, Reflector and Theorist learning styles than the general public. It could be that students choosing Open University courses have a preference for these styles, however, it is not possible to determine this from the data and other possible reasons exist as all the students in the Open University sample were also close to completion of a second level course. Since the learning styles measured by the Learning Styles Questionnaire are held by the authors to be dynamic and improve with practice (Honey and Mumford, 1995), the findings could also imply that Open University students through their studies had the opportunity to practice and improve in using the Activist, Reflector and Theorist learning styles.

Grasha-Riechmann Student Learning Styles Scales

On the GRSLSS the distance education sample were significantly different to the general public on the Avoidant, Collaborative, Independent, Dependent and Participative scales. As with the Honey and Mumford learning styles, Grasha (1996b, p. 171) also notes that students' learning style preferences in the GRSLSS "...can be changed and modified depending upon the classroom procedures used". So it is possible that experience of the Open University course structure had influenced students' preferences, but Grasha later comments that courses would have to have extensively used the related teaching style for students to shift from their preferred learning style.

Independent

The significantly greater preference for Independent studying shown by Open University students in this study is not an unexpected finding, as students taking on a distance education course would expect to spend much of their time working independently and therefore be more inclined to choose distance education over other forms of further education such as courses offered by adult education colleges which provide more traditional, less independent, classroom environments.

In addition to this students taking part in the study were a significant proportion of their way through the course. A large number of those who drop out, do so at the beginning of the course (Gibbs, 2003), and likely to include those who are less suited to independent study. The study sample would therefore naturally include a greater proportion of students who are more suited to this style.

Dependent

The presence of both Dependent and Independent styles suggest a bipolar dimension. However during the development of the Grasha-Riechmann Student Learning Styles Scales it was found that the pairing was not a dichotomy (Grasha, 1996b, p. 170). This finding is also reflected in the results for the Open University student population where there is a corresponding significantly reduced preference for the Dependent learning style but only a small negative correlation between the Dependent and Independent styles (Pearson $r = -0.335$, $p < 0.0001$). Although the significance of this correlation is high the actual value of the correlation is small, indicating that although it's a small value the possibility of it occurring by chance is very small.

Collaborative

Open University students have a higher preference for being Collaborative than the general populace. This cognitive style emphasises individuals' preference for learning environments that allow the sharing of ideas and working in groups (Riechmann and Grasha, 1974). As the courses offered by the Open University do offer many opportunities for students to work collaboratively, mainly via online collaboration or at summer school, the preference for this style expressed by the students could either be due to a deliberate choice of courses that offer this style of teaching and/or it is a reflection of students experience of the collaborative nature of Open University courses. Further analysis of Collaborative preference, described in Chapter 7, using gender and age range as factors shows these are not factors affecting Collaborative preference in the Open University sample.

Participant

Open University students had a greater preference for being Participant - wanting to take responsibility for getting the most out of the course - than the general populace. This increase in preference for the Participant style is quite likely a reflection of the type of student who studies with the Open University, as students are more mature, paying for the course themselves and have chosen to undertake further study often for self fulfilment ('The Open University: Background Information,' 2003).

Avoidant

Open University students had a greater preference for being Avoidant than the stated general population norms. Also evident in Open University sample is a strong, negative correlation between the Avoidant and Participant styles (Pearson $r = -0.623$, $p < 0.000$), this is very similar to Grasha's findings (1996b, p. 170), who also notes that there is a strong dichotomy between the Avoidant-Participant pair ($r = -0.69$ to -0.75), supporting the validity of the Open University sample.

A cursory examination of the data indicated a possible connection between Participant-Avoidant preferences and gender and type of course being taken and so a more detailed investigation was undertaken. The results of this investigation are detailed further in Chapter 7.

Differences in preference by gender

No gender specific differences in preference were found on any of the Grasha-Riechmann learning styles, but significant differences in preferences were found on the Honey and Mumford learning styles: Reflector ($\chi^2 = 18.89$, 4 df, $p = 0.0008$), Theorist ($\chi^2 = 22.70$, 4 df, $p = 0.0001$) and Pragmatist ($\chi^2 = 12.43$, 4 df, $p = 0.0144$). In all three styles males had a higher preference for the style than females.

A more detailed analysis of the data indicates that the gender related differences were also dependent on whether it was a sciences or arts based course. The results of these analyses are detailed in Chapter 7.

Conclusion

Normative data from a sample of 181 Open University distance education students taking second level courses was compiled for the Grasha-Riechmann Student Learning Styles Scales and the Honey and Mumford Learning Style Questionnaire. This was to create a set of norms for participants in a study using students on the "M206 Computing: an Object Oriented Approach" that were more comparable than the published norms based on the general population. Where significantly different sub-groups have been found separate tables of norms have been compiled for each.

The presence of significant sub-groups found within the normative data means that although it is possible to compare data with group norms, there is a good chance this will be over generalising and that a more accurate comparison would be obtained when comparing with the normative data for the relevant sub-group. Whilst the sub-group norms were developed specifically for the present study, they are useful for anyone wishing to carry out comparisons with distance education students.

Chapter 7.

Exploration of Differences Found in the Open University Distance Education Student Normative Data

Abstract

In this chapter a more detailed analysis of the normative data from the Honey and Mumford Learning Style Questionnaire and the Grasha-Riechmann Student Learning Styles Scales for a large sample of distance education students at the Open University was explored, following indications that the gender related differences previously found were also dependent on whether it was a Sciences or Arts based course. Significantly different preferences on the Honey and Mumford Learning Styles Questionnaire were found between the genders on all four of their styles. These differences were also found to be related to the type of course being taken. No significant differences relating to gender or course type were found on the Grasha-Riechmann Student Learning Styles Scales.

Introduction

In the previous chapter, analysis of normative data from Open University distance education students (OUDES) for the Grasha-Riechmann Student Learning Styles Scales (Riechmann and Grasha, 1974; Grasha, 1996a) (GRSLSS) and Honey and Mumford Learning Style Questionnaire (Honey and Mumford, 1986; 1995) (LSQ), it was noticed that there were significant differences between the genders on some of the scales and differences involving an interaction between gender and course type that warranted further investigation.

The normative data study discussed in this chapter was carried out to create norms based on a sample that was a closer approximation to the students being studied in the *M206 Computing: an Object Oriented Approach* than the published norms based on the general population. However, the presence of significantly different subgroups requires a more detailed picture to be made up of the OUDES sample so that an accurate comparison can be carried out when comparing the M206 students to distance education students in general.

This chapter explores in greater detail the findings from an OUDES normative data study discussed in Chapter 6. To enable a more accurate comparison to be made, individuals were grouped according to the OUDES norms rather than the published general population norms. In addition, GRSLSS raw scores were categorised using the five categories, based on the same criteria, employed in the LSQ. This provides GRSLSS with greater statistical flexibility than with the three categories used originally by Grasha and Riechmann. The norms for the five category comparison for GRSLSS are given in Table 7.1.

Style	**Very Low Preference (Lowest 10%)**	**Low Preference**	**Moderate Preference (Middle 40%)**	**Strong Preference**	**Very Strong Preference (Top 10%)**
Independent	1.0 – 3.0	3.1 – 3.4	3.5 – 3.9	4.0 – 4.2	4.3 – 5.0
Avoidant	1.0 – 1.9	2.0 – 2.3	2.4 – 2.9	3.0 – 3.4	3.5 – 5.0
Collaborative	1.0 – 2.6	2.7 – 3.1	3.2 – 3.9	4.0 – 4.4	4.5 – 5.0
Dependent	1.0 – 2.6	2.7 – 3.0	3.1 – 3.7	3.8 – 3.9	4.0 – 5.0
Participant	1.0 – 3.1	3.2 – 3.5	3.6 – 4.0	4.1 – 4.4	4.5 – 5.0

Table 7.1: Open University distance education student norms for the Grasha and Riechmann Student Learning Styles Scales using the Honey and Mumford five category style.

Findings

Honey and Mumford, Learning Styles Questionnaire

The findings from the OUDES normative data study in Chapter 6 showed significant differences between the genders on the *Reflector* ($\chi^2 = 18.89$, 4 df, p = 0.0008), *Theorist*

(χ^2 = 22.70, 4 df, p = 0.0001) and *Pragmatist* (χ^2 = 12.43, 4 df, p = 0.0126) scales. In all cases males had a greater preference than females for the style.

Following the discovery of additional significant differences between the genders in the proportions of each gender taking arts or science based courses (Chapter 6), it was deemed worthwhile to carry out further investigation looking at whether there was any relationship between learning style preference and course type as it may be that an individual's preference for a particular learning style might influence the type of course they chose to study.

Course type is defined here as either science or arts to be consistent with the definition used through the dissertation. Science subjects are those courses presented by the Maths and Computing, Science and the Technology Central Academic Units, while arts are those courses presented by the remaining Central Academic Units. This distinction is commonly used by the Open University.

In the OUDES study sample, four participants were noted to be taking a course in both the sciences and the arts. These cases were excluded from the analyses as the size of this group is not large enough for any analysis of it to have any meaningful interpretation.

Analysis of the distribution of learning style preferences indicates that although significant differences exist between the genders, course type was not found to have any significant effects (Table 7.2).

Learning Style	**Chi Square χ2 (4df)**	**Sig.**
Activist	3.419	p=0.4903
Reflector	7.165	p=0.1274
Theorist	7.788	p=0.0996
Pragmatist	4.624	p=0.3280

Table 7.2: Chi Square analysis values for differences in learning style preference distributions between science and arts courses.

The two course type groups were further subdivided to distinguish between the genders taking each course type. The four subgroups created are shown in Table 7.3.

	Art	Science
Female	Group 1 (AF): Art-Females	Group 2 (SF): Science- Females
Male	Group 3 (AM): Art-Males	Group 4 (SM): Science-Males

Table 7.3: Composition of subgroups used.

Figures 7.1-7.4, show the different distributions of learning style preferences for each of the subgroups within the OUDES sample for the Honey and Mumford learning styles. The graphs show the percentage of the total number in each subgroup, enabling a more accurate visual comparison to be made between sub-groups.

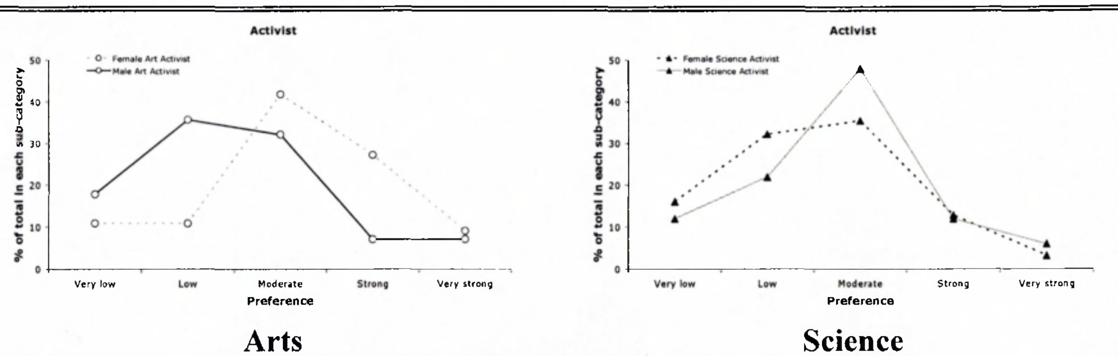
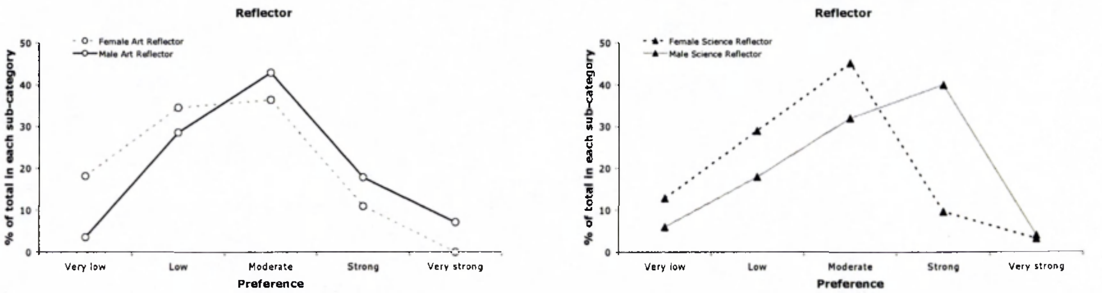


Figure 7.1: Frequency distribution plots comparing differences in preference for the Activist scale on the Honey and Mumford Learning Styles between genders for the arts and science subjects.

Although no difference was noted between the genders in general for the *Activist* style in the arts, a greater proportion of females appear to have a strong preference for the *Activist* style than males, and this is shown to be significantly different in a subsequent statistical analysis (Table 7.4). In the sciences, it appears that there are more males with a greater preference for the *Activist* style than males in the arts, and that females in the Sciences have less preference for the *Activist* style than females doing the arts, but in both cases these were found not to be significant (Table 7.4).

For the *Reflector* style (Figure 7.2), in the arts both genders follow roughly the same frequency distribution with slightly lower preference for the style in general. The sciences males, particularly in the 'strong preference' category, have an apparently greater preference for the Reflective style than females but this was not found to be significantly different (Table 7.4).

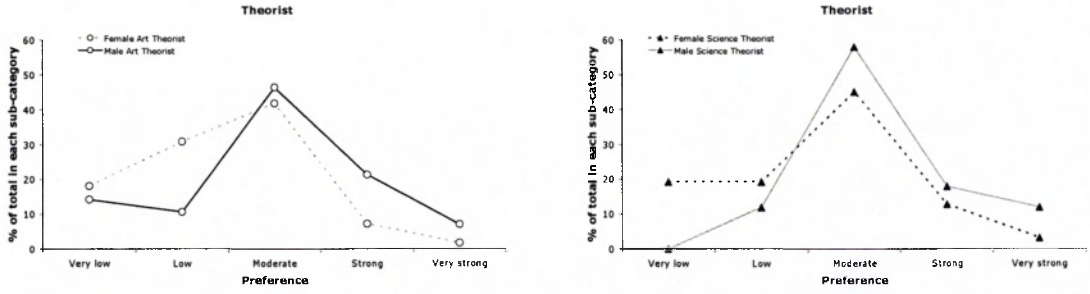


Arts **Science**

Figure 7.2: Frequency distribution plots comparing differences in preference for the Reflector scale on the Honey and Mumford Learning Styles between genders for the arts and science subjects.

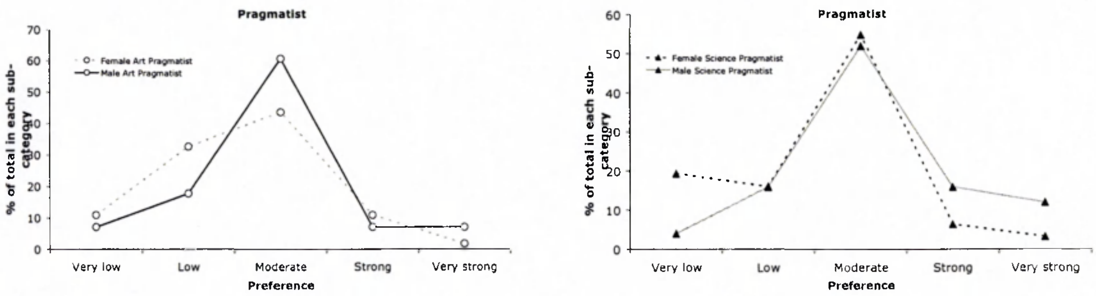
For the *Theorist* style (Figure 7.3), preferences between genders in the arts indicates the possible presence of differences with females having less preference than males for the *Theorist* style, however on analysis this lies outside the five percent level of significance (Table 7.4). In the sciences in contrast, there are no apparently obvious differences between the genders, but subsequent analysis (Table 7.4) indicates that males have a significantly greater preference for the *Theorist* style than females in the sciences.

The subgroups show very similar distributions of preference in the *Pragmatist* style (Figure 7.4) to those in the *Theorist* style. However subsequent analyses shows no differences between the genders in the arts or sciences, or differences between the arts and sciences within genders (Table 7.4).



Arts **Science**

Figure 7.3: Frequency distribution plots comparing differences in preference for the Theorist scale on the Honey and Mumford Learning Styles between genders for the arts and science subjects.



Arts **Science**

Figure 7.4: Frequency distribution plots comparing differences in preference for the Pragmatist scale on the Honey and Mumford Learning Styles between genders for the arts and science subjects.

Analyses carried out, found no difference between the genders in the arts or sciences, or differences between the arts and sciences within genders.

Table 7.4 details the analyses comparing the differences between genders for the arts and sciences for the LSQ, as well as exploring potential differences between the arts and sciences within each gender. Chi Square was used rather than an ANOVA because of the categorical data and small numbers involved.

Significant differences in preference were found between genders on some of the scales (*Activist* and *Theorist*) and noted to be dependent on whether students were taking arts or science based courses. However, no significant differences were found in the distribution of preferences within genders comparing those who took arts or science based courses, for example comparing arts and science for females (Group AF against Group SF).

Comparison	Activist	Reflector	Theorist	Pragmatist
	$\chi2$ (4df), *sig.*	$\chi2$ (4df), *sig.*	$\chi2$ (4df), *sig.*	$\chi2$ (4df), *sig.*
Group AF – Group AM	**10.803** *p=0.029*	7.999 *p=0.092*	7.940 *p=0.094*	4.578 *p=0.333*
Group SF – Group SM	1.781 *p=0.776*	9.226 *p=0.056*	**12.985** *p=0.011*	7.715 *p=0.103*
Group AF – Group SF	8.311 *p=0.081*	2.715 *p=0.607*	1.900 *p=0.754*	4.170 *p=0.383*
Group AM- Group SM	3.207 *p=0.524*	4.808 *p=0.308*	8.137 *p=0.087*	2.141 *p=0.710*

Table 7.4: Chi Square analysis values and levels of significance for differences in distribution of learning style preferences between the genders within each course type on the Honey and Mumford Learning Style. Significant results are highlighted in bold.

It is felt however, that this area is deserving of further study as many of the values obtained in both sets of statistical analyses were noted to lie just outside the five percent level of significance and goal seeking analysis showed that significance was achievable by the addition or change in category of one individual.

Grasha-Riechmann Student Learning Style Scales

Similar analyses were carried out on the Grasha-Riechmann Student Learning Style Scales, exploring relationships between course and gender on learning style preferences. To reduce the limitations of a three point scale and provide a similar scale of comparison with Honey & Mumford's learning styles, levels of preference on the GRSLSS for each participant were calculated on a 5 point scale based on the norms previously obtained for the OUDES sample and using the same percentile definitions as used by Honey and Mumford (1995).

As with the analysis of the LSQ, individuals were categorised into subgroups depending on gender and course (Table 7.3). The distribution of preferences for each scale on the

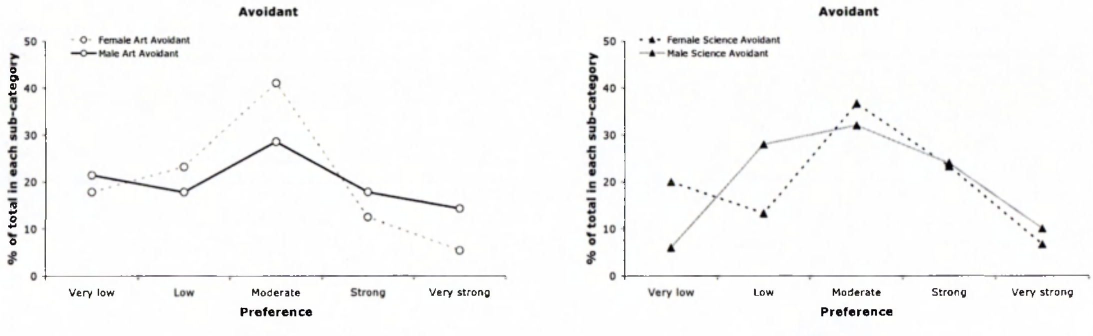
GRSLSS within each subgroup was then analysed. The results of the comparisons are presented graphically in Figures 7.5 – 7.9.

The original Chi-Square analysis carried out in Chapter 6, comparing the differences in preference between genders and course types was repeated, using the raw data re-categorised into the five categories, based on the same criteria, employed in the LSQ (Table 7.5). Analysis confirmed that no significant differences were present at the five percent level of significance.

Comparison	Avoidant	Collaborative	Independent	Participant	Dependent
	$\chi 2$ (4df), *sig.*	**$\chi 2$ (4df), *sig.***	**$\chi 2$ (4df), *sig.***	**$\chi 2$ (4df), *sig.***	**$\chi 2$ (4df), *sig.***
Art – Science	3.72 *p=0.445*	0.90 *p=0.925*	2.00 *p=0.736*	1.28 *p=0.865*	6.09 *p=0.193*
Female – Male	4.85 *p=0.303*	2.03 *p=0.730*	4.48 *p=0.345*	1.25 *p=0.870*	5.60 *p=0.231*

Table 7.5: Chi Square analysis values and levels of significance for differences in distribution of learning style preferences by course and gender on the Grasha and Riechmann Student Learning Style Scales.

For the Avoidant scale (Figure 7.5) there is fairly normal distribution in both the arts and science, although the distribution for males in the sciences is skewed towards a lower preference for the style. Subsequent statistical analysis shows no significant differences either between genders within each course type, or comparing between courses within each gender (Table 7.6)



Arts **Science**

Figure 7.5: Frequency distribution plots comparing differences in preference for the Avoidant scale on the Grasha and Riechmann Student Learning Style Scales between genders for the arts and science subjects.

Distribution of preferences for the Collaborative and Participant styles (Figure 7.6 and Figure 7.7) also follow the expected normal distributions with little difference between genders or between courses. Males' preference for the Participant style in the arts appears to be slightly more distributed than females' preference with a greater number of males than females indicating a preference for both the very low and very high categories, but this was not found to be significant (Table 7.6).

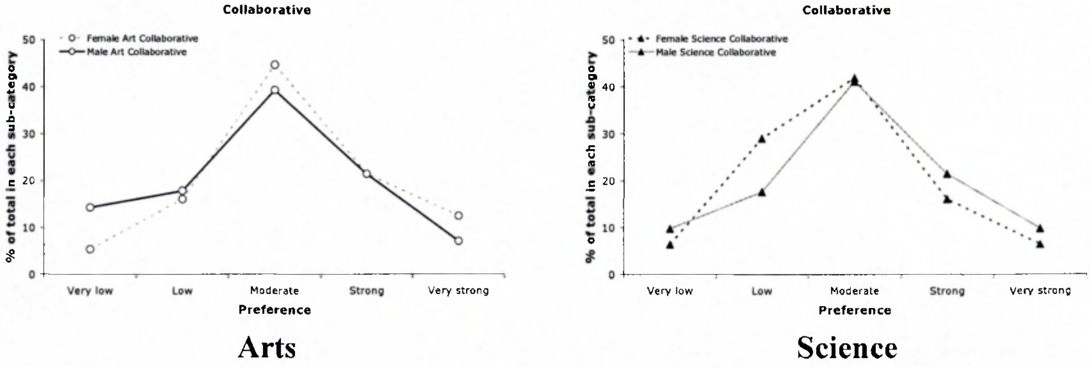


Figure 7.6: Frequency distribution plots comparing differences in preference for the Collaborative scale on the Grasha and Riechmann Student Learning Style Scales between genders for the arts and science subjects.

On the Independent scale (Figure 7.8), males doing arts subjects seem to have less preference for being independent than females as well as having less preference for being independent than males in the sciences. Neither comparison was found to be significant although the difference in distribution between males and females in the arts is just outside the five percent significance levels (Table 7.6).

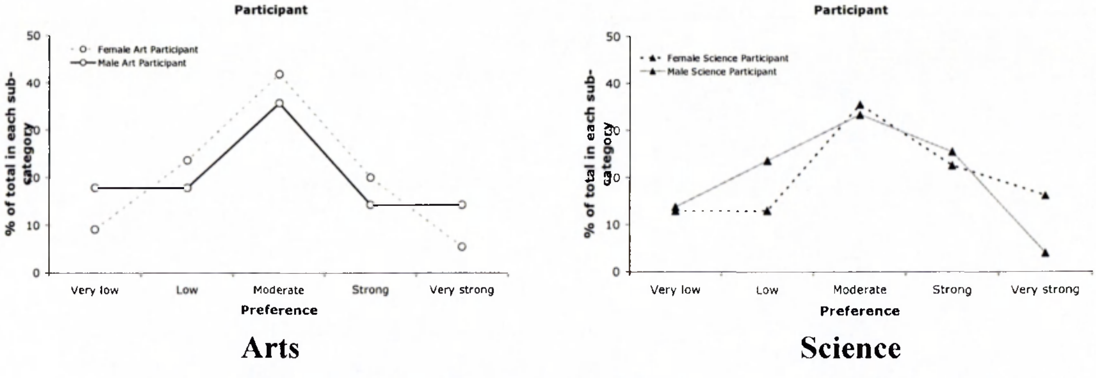
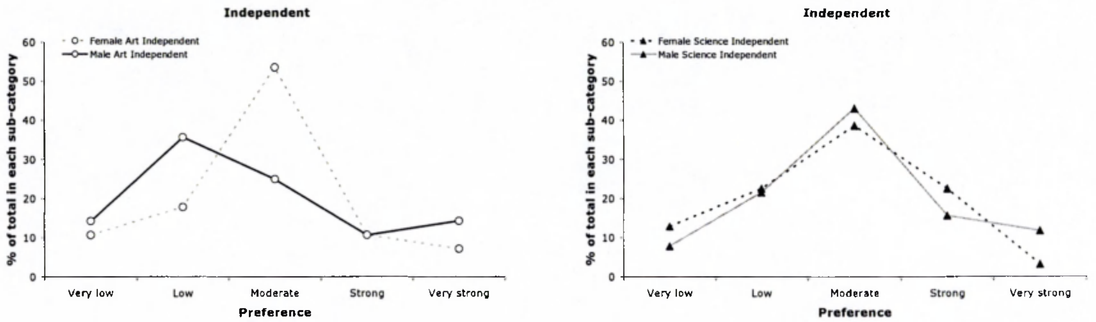


Figure 7.7: Frequency distribution plots comparing differences in preference for the Participant scale on the Grasha and Riechmann Student Learning Style Scales between genders for the arts and science subjects.

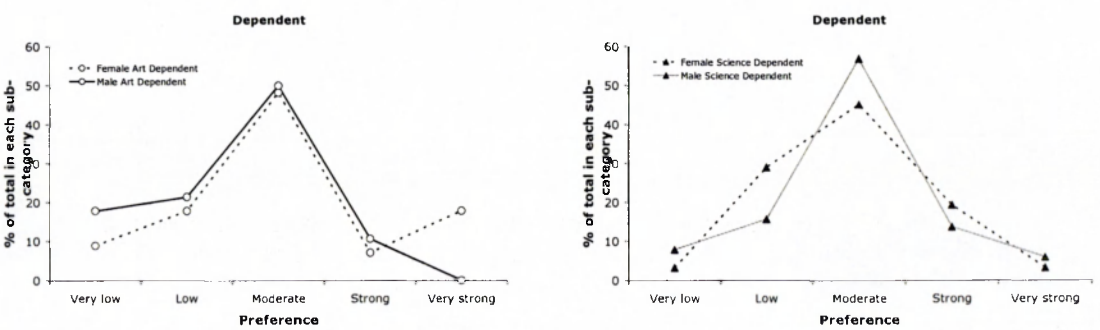
On the Dependent scale, subjects were again noted to follow the normal distribution in the arts. Males and females have almost identical distributions, but females show a slight increase in numbers for the very strong preference and males and slight increase in numbers for a very low preference. This was found to lie just outside the five percent level of significance (Table 7.6).



Arts **Science**

Figure 7.8: Frequency distribution plots comparing differences in preference for the Independent scale on the Grasha and Riechmann Student Learning Style Scales between genders for the arts and science subjects.

In the sciences, both females and males have almost normal distributions. The distribution for females however appear to be slightly skewed and therefore for females to have less preference for the Dependent style than males. This was not found to be significant in a subsequent analysis.



Arts **Science**

Figure 7.9: Frequency distribution plots comparing differences in preference for the Dependent scale on the Grasha and Riechmann Student Learning Style Scales between genders for the arts and science subjects.

Table 7.6 details the results of the analyses comparing the differences in distribution between the subgroups. No significant differences were found although several were noted be just outside the five percent level of significance and invite further investigation.

Comparison	Avoidant $\chi 2$ (4df) *sig.*	Collaborative $\chi 2$ (4df) *sig.*	Independent $\chi 2$ (4df) *sig.*	Participant $\chi 2$ (4df) *sig.*	Dependent $\chi 2$ (4df) *sig.*
Group AF – Group AM	3.33 *p=0.504*	2.45 *p=0.654*	7.16 *p=0.128*	3.69 *p=0.450*	6.67 *p=0.154*
Group SF – Group SM	2.16 *p=0.706*	1.94 *p=0.747*	2.75 *p=0.600*	4.58 *p=0.333*	3.50 *p=0.478*
Group AF – Group SF	2.57 *p=0.632*	2.69 *p=0.611*	3.64 *p=0.458*	4.12 *p=0.390*	8.09 *p=0.088*
Group AM- Group SM	5.13 *p=0.274*	0.48 *p=0.975*	4.13 *p=0.389*	4.11 *p=0.391*	3.86 *p=0.425*

Table 7.6: Chi Square analysis values and levels of significance for differences in distribution of learning style preferences by course and gender on the Grasha and Riechmann Student Learning Style Scales.

Discussion

The purpose behind the analyses was to check for the presence of significantly different sub-groups which could affect the interpretation of any research using the OUDES normative data sample as a comparison group. Significant sub-groups were found on the Honey and Mumford Learning Styles Questionnaire (LSQ), but not with the Grasha-Riechmann Student Learning Style Scales (GRSLSS). However, the level of significance in some areas was only just outside the five percent significance level indicating that further investigation is required.

Honey and Mumford Learning Styles Questionnaire

Course type (science or arts) was not found to affect the preference for any of Honey and Mumford's learning styles directly. On more detailed examination however it was found that the effect of gender, as noted in the normative data study (Chapter 6), was related to whether students were taking a science or arts based course.

A significant level of difference between the distributions of genders was noted in the arts on the *Activist* style and also with the sciences on the *Theorist* style. However, some of the other results looking at the differences between genders within course type and course type within genders were noted to be just outside the 5% level of significance. Goal seeking analysis also showed that the results, particularly those close to significance, were susceptible to very small variations within the data. Because of this it is difficult to draw general conclusions and the area is certainly deserving of further research.

Of interest is that no differences were noted between the genders for the *Activist* style in the normative data study, but in this investigation, in the arts, females were found to have a significantly greater preference for the *Activist* style to males. This suggests that, for students taking arts based courses, females have a greater preference than males for being 'hands on'. A significant level of difference was also found on the *Theorist* style in the sciences with males showing greater preference for the style and therefore better at analysing and generalising from a learning activity than females.

These differences can be explained to some extent from the fact that the learning styles measured by the LSQ are dynamic and capable of changing particularly with experience in using the styles (Honey and Mumford, 1995). In addition, the normative data explored here is of distance education students who are close to completion of a second level course. At the Open University whilst is it possible to take a second level course as the first course of study, most students will have had experience of a first level distance education course and may have had experience of other second level distance education courses as well. The possibility therefore exists that they may have been influenced by the pedagogical approaches applied in these courses. However, the differences found were between the genders rather than course type, which could be due to cognitive differences between the genders and a reflection of how each gender cognitively deals with the way specific pedagogical material is presented.

Grasha-Riechmann Student Learning Style Scales

In contrast to the LSQ, analyses of the GRSLSS found no differences in preference on the various sub-groupings for the Grasha-Riechmann learning styles and it is concluded that although a few values on the Independent and Dependent scales were close to significance, no cognitive differences exist between the genders or between course types for learning style preferences on the Grasha-Riechmann scales.

The styles measured by the GRSLSS are noted by the authors to be able to change, commenting that for these changes to occur students have to extensively experience a pedagogical method compatible with a particular style (Grasha, 1996a, p. 171). As no differences were found between the course types in this study, this implies that either there are no differences to be found or none were seen. Reasons for differences not being observed could include the pedagogical approaches used on courses by academic units in the Arts and Science being similar, if not identical, to each other, or that courses may not use a specific kind of approach extensively enough to influence students' preferences. In addition, the categorisation of course types into arts and science may be too coarse and such differences if they exist may only be seen at a finer level when comparing Central Academic Units or even specific courses.

Conclusions

The significant differences found between gender and course type sub-groups on the Honey and Mumford Learning Styles Questionnaire provides evidence of the mutability of the learning styles in the LSQ and that certain learning styles can change over time. It also supports the need to be aware of differences in sub-group preferences when using normative data on these scales as a comparison group.

No differences were found between genders, course types or sub-groups on the Grasha-Riechmann Student Learning Styles Scales. This supports the authors' statement that although the styles measured by the GRSLSS are capable of change they will only do so when subjected to extensive experience of a particular style, and that the norms obtained for the GRSLSS are more stable and less subject to the factors of course type and gender.

Chapter 8.

Development of the Questionnaire on Visual Verbal Strategies (English)

"The concept of individual differences in imaginal and verbal symbolic habits is obviously of little scientific value unless the differences can be reliably measured."

Paivio (1971)

Abstract

This chapter is concerned with the validation of the Questionnaire on Visual Verbal Strategies (English) ($QVVS_{Eng}$). After examination of individual items and comparison with other visual verbal questionnaires, a slightly revised version is produced, after removing those items not found to correspond well with their relevant scales. Cronbach's Alpha was 0.73 for the Visual scale and 0.54 for the Verbal scale. Norms are also given for a mixed group of 181 distance education students on the $QVVS_{Eng}$.

Introduction

This chapter is concerned with the validation of the Questionnaire on Visual Verbal Strategies (English) ($QVVS_{Eng}$), used to assess individuals' preference for visual and verbal cognitive processing strategies in the study of Chapter 5.

The issue of reliability and validity is an important one as reliability is essentially a measure of whether any scale or measure will if nothing changes give the same value measurement each time it is used, while validity pertains to the how well the actual scale or measure, quantifies what it is supposed to. Fuller discussion and comprehensive introduction to the issues of reliability and validity is given by Cronbach (1990).

Use of Questionnaires

At present self-evaluation questionnaires, also known as inventories, are the most used and convenient way to assess visual and verbal preferences, as these provide researchers as well as educators and trainers with an easy, reliable and validated way to distribute and assess individual requirements (Cronbach, 1990). In a review of literature on questionnaires by Walonick (2004), other advantages of questionnaires included cost effectiveness, particularly when compared against face-to-face interviews and the number of questions that need to be asked. He also found that questionnaires were familiar to most people, less intrusive than telephone or face-to-face interviews, and leave respondents free to complete it in their own time. The latter increasing the likelihood of respondents taking part.

Criticism's noted by Walonick (2004) in the use of questionnaires include the fact that questionnaires do not suit everybody, such as adults with basic literacy skills. Students taking part in this research nonetheless would already have demonstrated a good level of proficiency in literacy in order to be able to undertake the Open University course.

Another criticism is that the researcher is not present and therefore limited in their ability to probe responses which can loose the "flavor of the response" (Walonick, 2004). However, while applicable to surveys where more open response is desired, psychometric inventories such as the $QVVS_{Eng}$ use closed responses in comparison. The lack of a researcher being present also has an advantage of reducing 'interviewer bias' (Walonick, 2004), but Leutner and Plass (1998) suggest from their study that direct observation of students' behaviour in an authentic learning situation is a better alternative as self-reported questionnaire data is usually collected in a non-authentic learning situation and vulnerable to response sets.

Anther potential form of bias is the difference between responders and non-responders to questionnaires. Both Benson et al. (1951) and Gough and Hall (1977) report differences in responses between responders and non-responders, while others have found differences between those who respond late in comparison to those who respond early (Speer and Zold, 1971; Brown and Wilkins, 1978).

However, for this research a questionnaire format was chosen because participants were distance education students where direct observation was both impractical and offered no significant methodological advantages over the use of questionnaires.

Imagery versus Verbal ability

Assessments of individual differences in visual and verbal processing have been measured since Galton's (1883) 'Breakfast Table' questionnaire which is cited by Paivio (1971) as being the first systematic investigation into this concept. However, after this there was little research undertaken during the first half of the twentieth century looking at mentalist concepts such as visual and verbal cognitive processes because there was no room for these ideas in the stimulus-response psychology prevalent at the time. Interest in the topics of visual and verbal processing never died out as they were necessary for a full account of behaviour and this is reflected in the increasing number of studies of visual and verbal cognitive processing that have been occurring since mid twentieth century (Paivio, 1971a). A brief review of some visual and verbal questionnaires follows including details of the $QVVS_{Eng}$.

The Individual Differences Questionnaire (IDQ)

The Individual Differences Questionnaire was developed by Paivio (Paivio, 1971a p. 495-7), following the resurgence of interest in visual and verbal processing around that time and to overcome shortcomings in the currently available imagery scales, such as

Betts Inventory (Betts, 1909), Sheehan's revised version of Betts Inventory (Sheehan, 1967) and Mark's Vividness of Visual Imagery Questionnaire (Marks, 1973), which often failed to show correlations with objective performance on tasks where good images would presumably be helpful, they also generally lacked controls for response sets of acquiescence and social desirability.

The IDQ is an 86-item true-false self-assessment questionnaire based also on Paivio's Dual Coding Theory perspective and was designed to measure the extent to which individuals habitually used verbal or visual methods for thinking. The questionnaire controlled for response sets through the use of negatively worded items. Paivio comments that the IDQ was not developed as a formal measurement device, but it aroused significant interest in the research community to such an extent that it persuaded Paivio to publish the actual questionnaire and the findings of a factorial study carried out on it, some years after it had been developed (Paivio and Harshman, 1983). However, only a subset of the questions measure visual and verbal preferences.

The Visual Verbal Questionnaire (VVQ)

The Visual Verbal Questionnaire was developed by Richardson (1977) as part of a search for a better way of measuring the vividness of mental images and to tie in with converging research in cognitive hemispheric specialisation and laterality of eye movement. It was developed using 15 items taken from Paivio's Individual Differences Questionnaire or Ways of Thinking (WOT) questionnaire[1] [sic], because it was less susceptible to bias from response sets. However the VVQ is scored on the assumption

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1 Richardson calls Paivio's questionnaire the "Ways of Thinking" (WOT) questionnaire, but in later work Paivio calls his questionnaire the "Individual Differences Questionnaire".

that visual and verbal attributes are at opposite ends of a bipolar scale, which is not supported by research (Kirby et al., 1988; Antonietti and Giorgetti, 1996). There are also other criticisms of the questionnaire appearing in various studies including poor reliablity, poor item discrimination, and a high degree of bias in answers (Antonietti and Giorgetti, 1992; 1996; Graham, 1997; Antonietti and Giorgetti, 1998; Leutner and Plass, 1998).

The Index of Learning Styles (ILS)

The Index of Learning Styles (Felder and Soloman, 1991) is used to assess an individual's preferences on the four dimensions of a learning style model originally devised by Felder and Silverman (Felder and Silverman, 1988; Felder, 1993), which includes a visual/verbal dimension. Visual and verbal preferences are measured as a single dimension, not separately, leaving the questionnaire open to the same criticism as Richardson's VVQ. The ILS is also not validated, although the author comments that he is carrying out a fairly extensive validation study on it and that Cronbach's alpha (a model of internal consistency, based on the average inter-item correlation (*SPSS for Windows,* 2002)) for the visual/verbal scale has been determined in separate studies to be 0.60, 0.56, 0.69, and 0.63 (Personal communication: Felder, 26/01/2003) (Appendix C).

The Questionnaire on Visual and Verbal Strategies (QVVS)

The Questionnaire on Visual and Verbal Strategies (Antonietti and Giorgetti, 1993) measures an individual's preference for visual and verbal strategies when processing information. The questionnaire conceptualises visual and verbal information processing as orthogonal constructs, rather than being at opposite ends of a single bi-polar scale. The QVVS is also short, containing just 18 questions, giving it the advantage of being quick to administer and improving its acceptability to participants, particularly when combined in a battery of other psychometric tests.

Validity studies carried out on the QVVS by Antonietti and Giorgetti (1993) compared it against three questionnaires, Richardson's VVQ, discussed earlier, the Styles of Learning and Thinking questionnaire (SOLAT®) by Torrance et al (1977), which examines individual preferences for hemisphere specialisation, and a questionnaire by Brown (1987) created to help individuals assess their own relative preference for visual, acoustic or kinetic modes of memory. The latter, Brown (1987) describes as those modes of memory involving motion, such as our own movements or movements of others, and where demonstration is the most effective form of communication.

Your Style of Learning and Thinking (SOLAT®)

The SOLAT® (Torrance et al., 1977) is a self-administered questionnaire, measuring individuals' preferences for left or right sided hemispheric specialisation and integration. The preliminary version described has two forms: Form A, developed in November 1975, consists of 36 items, and Form B, developed in May 1976, has 40 items. Most items from Form A are included in Form B, but have been rewritten to simplify or clarify their meanings. In both Forms, each item describes 3 ways of thinking or learning and participants choose which of the three describes their strengths or weaknesses. An individual's preferences for Right, Left or Integrated hemispheric specialisation is then calculated according to the scoring key provided and compared to the Norms provided for various groups of students.

Torrance et al., report that the reliability between the two different forms carried out on a sample of 50 undergraduates is 0.84 for right hemispheric laterality, 0.74 for left hemispheric laterality and 0.85 for their integrative style. The repeated measure reliability, carried out on a sample of 20 undergraduates over 6 weeks, produced a reliability factor of 0.84. Although a number of items in the SOLAT® can be readily identified as relating to visual and verbal preferences, in Form B they only account for 13 of the 40 items with the remaining items focussed on other areas of differentiation between hemispheric specialisation.

The use of the SOLAT® as a comparison tool was considered as it had been used in the comparison with the original Italian version (Antonietti and Giorgetti, 1993). However, a decision not to use it was taken as its focus was on hemispheric lateralisation rather than visual and verbal preferences and there were difficulties obtaining the rights to use it from the current copyright holders.

Memory Styles

Brown's Memory Styles questionnaire (1987) consists of 12 items. Each item presents a question from which individuals have to choose one of three alternative answers that suits them best. Each answer represents either the acoustic, visual or kinetic memory mode. An Individual's primary memory modality is calculated from which mode(s) were selected the most often. Some research has been done by Brown over several years to develop an expanded version of the questionnaire, but he has been unable to get the three factors to fall out cleanly and has also found problems with reliability on repeated administration (Personal correspondence, Brown, 19/06/2003) (Appendix C).

The QVVS however was developed and written in Italian. An English translation of the questionnaire was produced with the help of an Italian colleague, but because of linguistic and cultural differences which have been shown to affect the way we process information and therefore responses to psychometric tests (Ellis and Hennelley, 1980;

Naveh-Benjamin and Ayres, 1986; Hoosain and Salili, 1988) the validity studies carried out on the original Italian version are not applicable to the English version.

This chapter details the separate validity studies carried out on the Questionnaire on Visual and Verbal Strategies English Version ($QVVS_{Eng}$) and the normative data values obtained for a population of distance education students. The method of selecting and evaluating a random sample of distance education students has already been described in an earlier chapter (Chapter 5).

Method

Administration of the Questionnaire on Visual and Verbal Strategies (QVVS)

The $QVVS_{Eng}$ is a self-assessed, 18 item questionnaire composed of 9 items asking about visual strategies and 9 items about verbal strategies that people use. The individual items along with their respective item number are detailed in Table 8.1. For each item, participants are asked to rate how often they use the strategy described on a scale of 1-5 (where 1 is very low and 5 is very high).

Items used in the $QVVS_{Eng}$ were translated directly from the original, but were not validated before use. The extent to which the use of literal translations have influenced responses is as yet unknown and the object of future work.

For the present study, the $QVVS_{Eng}$ was distributed as an electronic version that could be completed by participants online via a password protected webpage. This was to match the conditions in which it was originally distributed for the study looking at the learning styles of M206 students (Chapter 5), and to allow it to be distributed as part of a battery of other online psychometric tests.

Visual Items: Listed with item number	Verbal Items: Listed with item number
1. If I have to memorise a telephone number I picture the digits in my mind.	3. When I remember something I've memorised, I can recall exactly the words that appeared in the text.
2. When I hear or read a particular word, images which refer to that word come to my mind.	5. Often I find the solution to a problem by using mathematical formula, logical principles or abstract concepts.
4. If I have to get something to work I prefer to have a sequence of pictures which explain what needs to be done.	7. Before falling asleep I happen to repeat verbally things happened during the day.
6. When somebody tells me something, in my mind I picture images of what I'm being told.	9. When I have to go somewhere I don't know and ask for directions to somebody passing by, I memorise the words that person tells me.
8. I can't remember where I've put something. I visualise actions that I've done or places where I've been in order to find out where the object is now.	11. I happen to make up in my mind conversations on future situations.
10. When I read a story, I visualise the situations and the characters described.	12. When somebody describes a fact to me, I prefer if the fact is presented exclusively using words, orally or in writing.
15. When I have to go somewhere I know using public transport, I picture in my mind images of the itinerary and the path I will follow with the various means of transport.	13. When I have to draw an object, I recall in my mind its characteristics.
17. After listening to the description of a person I don't know, I remember the image I've made in my mind of what that person looks like.	14. I like to solve verbal puzzles, such as crosswords, anagrams, etc.
18. When I have to remember something, I try to make up images or association of images.	16. While I'm studying, I try to fix in my mind verbal expressions which have to do with the situation – for instance a physical phenomena, an historical fact or a place – which is described in the text.

Table 8.1: Items on the Questionnaire of Visual and Verbal Strategies (English)

Results

181 distance education students studying for a second level course at the Open University completed the questionnaire. The mean score and standard deviation for each test item is detailed in Table 8.2 and shown graphically in Figure 8.1.

Visual Items	Mean	Std Dev	Verbal Items	Mean	Std Dev
Q1.	2.0608	1.3629	**Q3.**	2.6354	1.2779
Q2.	2.9171	1.2377	**Q5.**	2.8950	1.3354
Q4.	3.0055	1.2931	**Q7.**	1.6740	1.0692
Q6.	2.9392	1.2300	**Q9.**	3.1436	1.2299
Q8.	4.0552	1.1042	**Q11.**	3.5083	1.3022
Q10.	4.1105	1.1494	**Q12.**	2.9503	1.1845
Q15.	3.0331	1.3659	**Q13.**	3.5028	1.0730
Q17.	3.1381	1.2282	**Q14.**	3.3812	1.4195
Q18.	3.0884	1.2618	**Q16.**	3.0166	1.1854

Table 8.2 Item means and standard deviations obtained on the Questionnaire of Visual and Verbal Strategies from a sample of 181 distance education students.

The ideal mean score for individual items should be around 3 (median value between 1 and 5) to provide the greatest possible discrimination. Most items were found to have means close to this median, but three questions were found to have lower discrimination. Question 7 was found to be consistently given a lower than normal score (mean = 1.67), while Questions 8 and 10 tended to be consistently given scores higher than normal (mean 4.06 and 4.11 respectively).

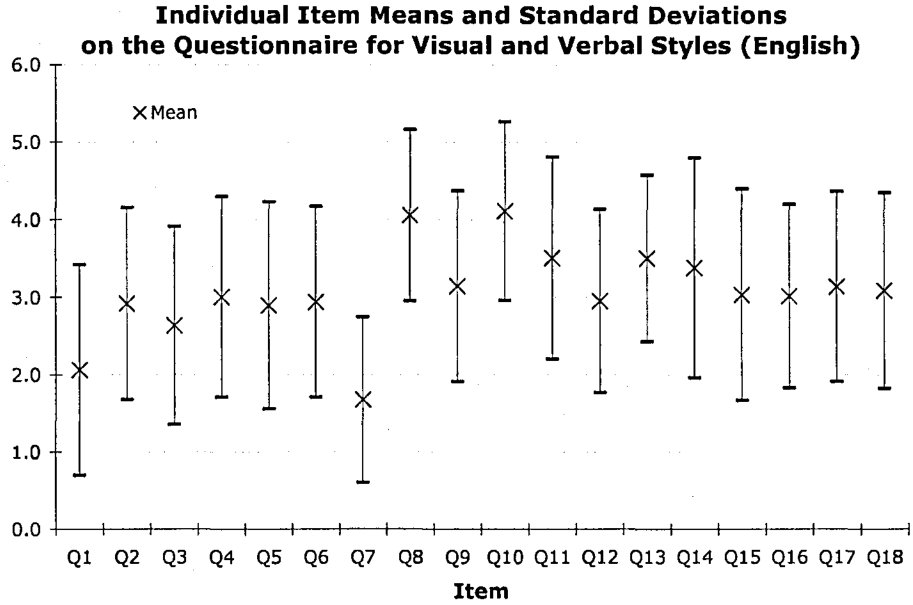


Figure 8.1 Mean score for individual items and error bars showing 1 standard deviation, obtained on the Questionnaire on Visual and Verbal Strategies for a sample of 181 distance education students.

Internal Consistency

Cronbach's alpha (α) (Cronbach, 1990) for the visual and verbal items was calculated separately.

Visual α = 0.7337

Verbal α = 0.5215

Although the Cronbach alpha coefficient for the verbal scale is low, it is above the 0.5 minimum recommended by Tuckman (1998) and indicates that questionnaire's internal consistency (a measure of validity) is above the recommended minimum for both the visual and verbal scales.

Item Correlations

The score on individual items was correlated against the total score for both the visual and verbal categories as a measure of individual item construct validity (Table 8.3 and Table 8.4).

Visual Items		Visual Score	Verbal Score	Verbal Items		Visual Score	Verbal Score
QS1	$r_{Pearson}$	0.569	0.147	**QS3**	$r_{Pearson}$	0.186	0.449
	Sig. (2-tailed)	p<0.0001	p=0.048		Sig. (2-tailed)	p=0.012	p<0.0001
QS2	$r_{Pearson}$	0.667	0.218	**QS5**	$r_{Pearson}$	-0.104	0.251
	Sig. (2-tailed)	p<0.0001	p=0.003		Sig. (2-tailed)	p=0.165	p=0.0006
QS4	$r_{Pearson}$	0.341	-0.068	**QS7**	$r_{Pearson}$	0.234	0.401
	Sig. (2-tailed)	p<0.0001	p=0.365		Sig. (2-tailed)	p=0.0015	p<0.0001
QS6	$r_{Pearson}$	0.608	0.136	**QS9**	$r_{Pearson}$	0.178	0.461
	Sig. (2-tailed)	p<0.0001	p=0.069		Sig. (2-tailed)	p=0.0166	p<0.0001
QS8	$r_{Pearson}$	0.416	0.171	**QS11**	$r_{Pearson}$	0.200	0.415
	Sig. (2-tailed)	p<0.0001	p=0.022		Sig. (2-tailed)	p=0.007	p<0.0001
QS10	$r_{Pearson}$	0.564	0.249	**QS12**	$r_{Pearson}$	-0.017	0.467
	Sig. (2-tailed)	p<0.0001	p=0.001		Sig. (2-tailed)	p=0.824	p<0.0001
QS15	$r_{Pearson}$	0.548	0.287	**QS13**	$r_{Pearson}$	0.313	0.375
	Sig. (2-tailed)	p<0.0001	p<0.0001		Sig. (2-tailed)	p<0.0001	p<0.0001
QS17	$r_{Pearson}$	0.541	0.349	**QS14**	$r_{Pearson}$	0.023	0.405
	Sig. (2-tailed)	p<0.0001	p<0.0001		Sig. (2-tailed)	p=0.759883	p<0.0001
QS18	$r_{Pearson}$	0.637	0.171	**QS16**	$r_{Pearson}$	0.351	0.637
	Sig. (2-tailed)	p<0.0001	p=0.022		Sig. (2-tailed)	p<0.0001	p<0.0001

Table 8.3: Visual item correlations against total visual score and total verbal score.

Table 8.4: Verbal item correlations against total visual score and total verbal score

All visual items were found to have significant correlations with the total visual score, and most items also have strong correlation with values between $r_p = 0.67$ and $r_p = 0.54$. Questions 4 and 8, although having highly significant correlations, have weaker values of $r_p = 0.431$ and $r_p = 0.416$ respectively. Question 4 has the weakest correlation ($r_p = 0.341$). Visual items were noted to have much smaller or non-significant correlations with total verbal scores ranging from $r_p = -0.068$ to $r_p = 0.349$.

All verbal items in general again had highly significant correlations with the total verbal score, but correlation values in general were found to be less than those found for visual items, in the range $r_p = 0.449$ to $r_p = 0.401$, the exceptions being question 16 with a high correlation ($r_p = 0.637$) and questions 5 and 13 with much lower correlations of $r_p = 0.251$ and $r_p = 0.375$ respectively. As expected, verbal items had much lower correlations with the total visual score with correlations ranging from $r_p = 0.351$ (question 16) to $r_p = -0.104$ (question 5).

Content Validity

An additional gauge to the validity of individual items was carried out by creating item characteristic curves (Cronbach, 1990). These were drawn up by plotting the mean score obtained for individual item at various levels of the overall total score on that scale (Figure 8.2 and Figure 8.3) and reflect the item correlations. Questionnaire items noted to have correlations with their respective scales below $r_p = 0.4$ or reduced discrimination by having an overall mean score above 4.0 or below 2.0, have been highlighted and labelled.

In general, visual items follow a pattern consistent with the expected, that is, participants giving individual visual items a lower score when their overall visual score is low and vice versa. Questions 8 and 10, noted earlier to have reduced discrimination, that is, being given high scores even when the overall visual score is low, do however still follow a pattern of consistently increasing with the overall visual score.

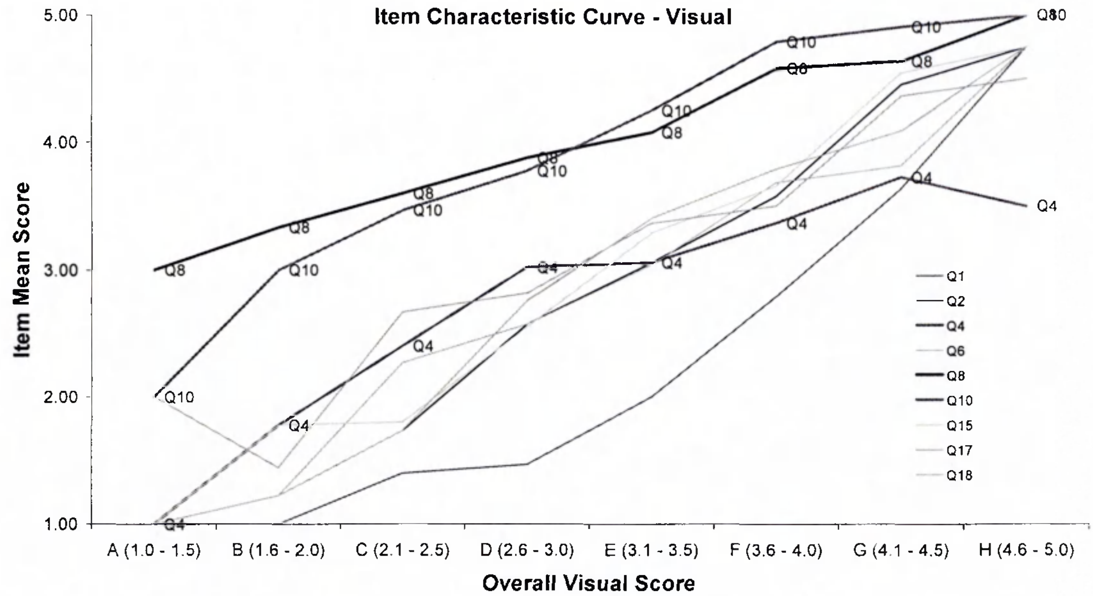


Figure 8.2 Item characteristic curve for visual items.

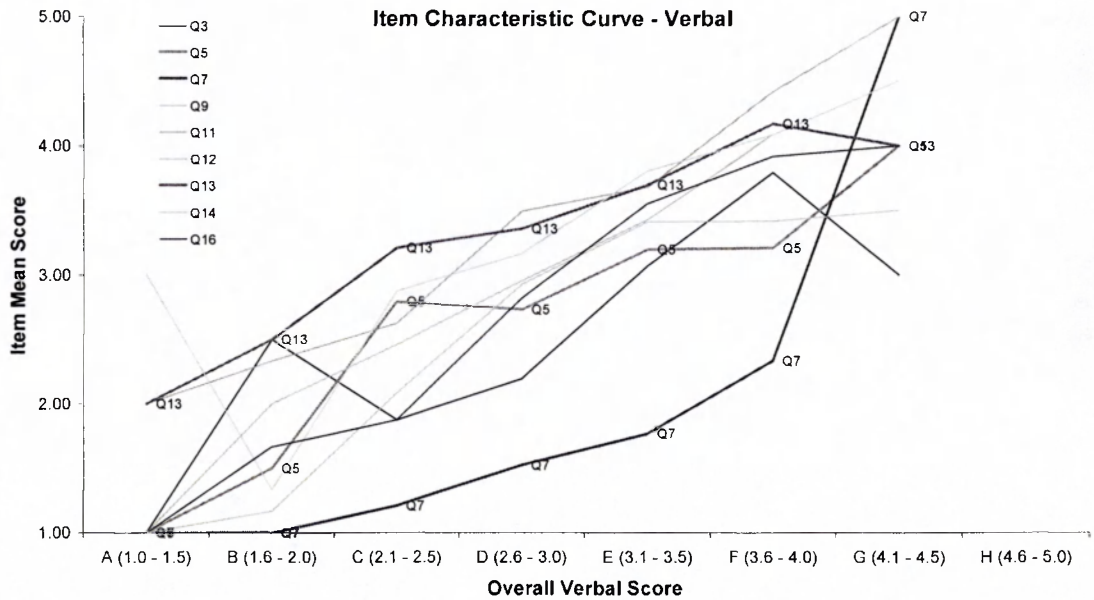


Figure 8.3 Item characteristic curve for verbal items.

Question 4 which has the lowest item correlation with the overall visual score (r_p = 0.341) has high discrimination when the overall visual score is low, but for higher overall visual scores it has very little variability and therefore little discriminatory value.

Question 17 has an anomaly in its item characteristic curve, and drops at the beginning before rising indicating that those who had an overall visual item mean test score below 1.6 generally scored this question higher than those who had an overall visual item score mean of between 1.6 and 2.0. Closer examination of the data however indicates that this could be an anomaly due to the very small number of participants (n = 3) who got an overall visual item mean test score below 1.6, and is deserving of further investigation.

In general, the individual item characteristic curves for verbal items follow a similar and expected pattern to visual items, but there are some notable differences. In particular, there is no overall verbal score achieved higher than 4.5 and the individual item characteristic curves are also much more varied than for visual items.

Looking at the individual items, Question 7, noted already to have poor correlation and poor discrimination, can be seen to change very little, consistently being given a low score for much of the range of total verbal score, before dramatically changing from an mean of just over 2.0 to a mean of 5.0 given by those with an overall verbal score of 4.0. As with Question 17 however the sudden increase could be an effect of the small number of participants with an overall verbal score of 4.0 (n = 5).

Question 5 noted to have a poor correlation with the overall verbal score can be seen follow a pattern similar to Question 4 showing great variability early on for total verbal scores under 2.5, but for the remainder of the range of overall total scores has little and inconsistent variability.

Question 13 is also noted to have a poor correlation, but its item characteristic curve is more uniform in comparison to Question 3 which can be seen to vary yet has a higher overall correlation. Investigation indicates that much of this, as with other anomalies noted, is most probably due to the way the individual item characteristic curve was set up and that the variations are due to the small numbers of individuals representing the extreme categories of the overall verbal score.

Comparison of $QVVS_{Eng}$ with other visual verbal questionnaires.

The $QVVS_{Eng}$ was also compared to previous questionnaires designed to measure visual and verbal strategies. The original, Italian QVVS has already been compared with Brown's Memory Styles and the SOLAT®. However, after examination of the items it was not felt appropriate to repeat the comparison with the SOLAT® questionnaire. Instead, Brown's Memory Styles together with Paivio's IDQ was used in substitution for the SOLAT®, as the latter has been widely used and concentrates on visual and verbal abilities.

In a small study, volunteers (N = 26) were asked to complete three questionnaires, the $QVVS_{Eng}$, Paivio's IDQ and Brown's Memory Styles. Individuals' scores on each scale of the questionnaires were then correlated each other (Table 8.5).

		QVVS Visual	QVVS Verbal	IDQ Visual	IDQ Verbal	Brown Visual	Brown Verbal	Brown Kinetic
QVVS Visual	r_p =	1.000	0.293	**0.673**	-0.132	-0.278	-0.018	0.287
	Sig.		p=0.146	**p<0.0001**	p=0.539	p=0.168	p=0.930	p=0.156
QVVS Verbal	r_p =	0.293	1	0.184	-0.078	-0.116	-0.004	0.181
	Sig.	p=0.146		p=0.389	p=0.716	p=0.572	p=0.983	p=0.376
IDQ Visual	r_p =	**0.673**	0.184	1	-0.248	-0.119	-0.066	0.188
	Sig.	**p<0.0001**	p=0.389		p=0.242	p=0.581	p=0.761	p=0.379
IDQ Verbal	r_p =	-0.132	-0.078	-0.248	1	-0.122	0.285	-0.230
	Sig.	p=0.539	p=0.716	p=0.242		p=0.571	p=0.177	p=0.281
Brown Visual	r_p =	-0.278	-0.116	-0.119	-0.122	1	-0.263	**-0.607**
	Sig.	p=0.168	p=0.572	p=0.581	p=0.571		p=0.194	p=**0.001**
Brown Verbal	r_p =	-0.018	-0.004	-0.066	0.285	-0.263	1	**-0.583**
	Sig.	p=0.930	p=0.983	p=0.761	p=0.177	p=0.194		p=**0.002**
Brown Kinetic	r_p =	0.287	0.181	0.188	-0.230	**-0.607**	**-0.583**	1
	Sig.	p=0.156	p=0.376	p=0.379	p=0.281	p=**0.001**	p=**0.002**	

Table 8.5: Comparison of $QVVS_{Eng}$, IDQ and Brown's Memory Styles showing intra and inter correlations between scales. Significance levels given are two tailed.

In their comparison, Antonietti and Giorgetti found that the visual and verbal scales of the Italian QVVS did not map onto any of the three scales (visual, verbal, kinetic) measured by Brown's Memory Styles questionnaire. This was also found to be the case with the $QVVS_{Eng}$ where visual and verbal scales were again found to have no correlation with any of Brown's scales on the Memory Styles questionnaire. Brown's Kinetic style was found however to have strong significant intra-item correlations with the Visual and Verbal scales on the Memory Styles questionnaire. This corresponds to Brown's own findings of not being able to get the three factors to separate out cleanly.

In comparisons with the IDQ, the visual scale on the $QVVS_{Eng}$ was found to have a very strong significant correlation with the visual scale of the IDQ ($r_p = 0.673$, $p<0.0001$). However, there was no correlation found between the verbal scale of the $QVVS_{Eng}$ and the verbal scale of the IDQ.

Revision of the Visual and Verbal scales on the $QVVS_{Eng}$

Examination of the individual items on the $QVVS_{Eng}$ and the visual and verbal scales overall suggests that the $QVVS_{Eng}$ has a valid construction at least on the visual scale. It is possible however, that the $QVVS_{Eng}$ and IDQ measure different constructs, but the visual items on both scales share a common cognitive process, while the verbal processes on both scales do not, which would explain the correlation found between visual items, but not the verbal. This is supported by the presence of significant intra-item correlations and an acceptable alpha coefficient on the verbal scale of the $QVVS_{Eng}$.

Nonetheless, the examination of individual items above indicate that a few of them are weak, either having a poor correlation with their associated scales or poor discrimination through being given a consistently high or low score regardless of the individual's overall score on the respective scale. Based on this, two items on the verbal scale were removed to improve the validity of the $QVVS_{Eng}$: item 5 and item 7.

Recalculation of Cronbach's Alpha, using the revised verbal scale, shows an improvement from 0.52 to 0.54. The correlation of the individual verbal items with the verbal total score also improves (Table 8.6).

Item		**Correlation with: Verbal Revised Scale**
Q3	$r_p =$	0.515
	Sig.	p<0.0001
Q9	$r_p =$	0.529
	Sig.	p<0.0001
Q11	$r_p =$	0.495
	Sig.	p<0.0001
Q12	$r_p =$	0.527
	Sig.	p<0.0001
Q13	$r_p =$	0.401
	Sig.	p<0.0001
Q14	$r_p =$	0.493
	Sig.	p<0.0001
Q16	$r_p =$	0.656
	Sig.	p<0.0001

Table 8.6: Individual verbal item correlations with the revised Verbal Scale on the Questionnaire of Visual and Verbal Strategies (English)

Norms

Norms for the $QVVS_{Eng}$ were calculated using the sample of responses from 181 distance education students at the Open University and were based on the revised verbal scale. Two sets of norms are given. Table 8.8 shows the norms using the levels of preference set out by Honey and Mumford (1995) (see Table 8.7) while Table 8.9 shows the norms for every 10^{th} percentile.

Very low preference	Lowest 10%
Low preference	Next 20%
Moderate preference	Middle 40%
Strong preference	Next 20%
Very strong preference	Highest 10%

Table 8.7: Summary of levels of preference after Honey and Mumford (1995),

	Very Low Preference (Lowest 10%)	Low Preference	Moderate Preference (Middle 40%)	Strong Preference	Very Strong Preference (Highest 10%)
Visual	9 – 21	22 – 26	27 – 31	32 – 36	37 – 45
Verbal	7 – 17	18 – 20	21 – 25	26 – 28	29 – 35

Table 8.8: Normative data for the Questionnaire on Visual and Verbal Strategies (English) based on a sample of 181 distance education students, using categories as set out by Honey and Mumford (1995)

	Percentile									
	0-10	*11-20*	*21-30*	*31-40*	*41-50*	*51-60*	*61-70*	*71-80*	*81-90*	*91-100*
Visual	9-21	22-24	25-26	27	28-29	30	31	32-33	34-36	37-45
Verbal	7-17	18-19	20	21	22	23	24-25	26	27-28	29-35

Table 8.9: Normative data for the Questionnaire on Visual and Verbal Strategies (English) based on a sample of 181 distance education students, showing norms for every 10^{th} percentile.

Discussion

In this chapter, the $QVVS_{Eng}$ was validated and norms produced based on a modified version of the questionnaire following the assessment of individual items and removal of two items on the verbal scale that were found to have poor discrimination or poor correlation with the verbal scale construct.

The $QVVS_{Eng}$ was found to have an internal consistency above the recommended minimum for both the visual and verbal scales. In addition, examination of the individual items on the visual and verbal scales indicate that is a good underlying level of validity in the questionnaire's construction.

The $QVVS_{Eng}$ was compared against two other questionnaires, Brown's Memory Styles and Pavio's IDQ. The $QVVS_{Eng}$ was not found to correlate on any scale with Brown's Memory Styles questionnaire and only on the visual scale with the IDQ. However, Brown reports problems in getting the three factors his questionnaire purports to measure to separate out cleanly, and it is interesting to note that no correlations were found between any of the scales on Brown's Memory Styles and Pavio's IDQ. Antonietti and Giorgetti, the authors of the original Italian version of the QVVS, also failed to find a relationship between any of the items on the QVVS and Brown's questionnaire. Although Brown's Memory Styles may measure a different construct to that of the IDQ or the QVVS, Brown's own reports of having trouble in separating out the three factors being measured by his questionnaire would seem to indicate that failure to correlate with other measures is due more to a problem in the item construction on this scale.

As discussed earlier, is it also possible that the $QVVS_{Eng}$ and IDQ measure different constructs as well, since the $QVVS_{Eng}$ has good intra-item correlations on the verbal scale as well as an acceptable alpha coefficient. Examination of verbal items on the IDQ shows that they cover a number of aspects of verbal usage such as the use of words and recall of verbal information, while verbal items on the $QVVS_{Eng}$ are focussed on mainly the recall of verbal information. This is seen in particular with the significantly high correlation that item 16 has with the verbal scale, which asks about memorising verbal expressions, associated with what is being described in the text.

As research into visual and verbal abilities has progressed it has become clearer that each area is made up of more specialised cognitive processes and consequently it is more difficult to generalise these. An example is given by Harshman and Paivio (1987) where they noticed the anomaly between females found to be doing better on visual scales than males, but males doing better than females on paper and pencil tests of visual ability. Their work suggested a third modality which is now recognised as 'spatial' ability and dealt with by a different cognitive process than visual imagery (Kozhevnikov et al., 2002).

Chapter 9.

Learning Styles and Observed Behaviour of Distance Education Students

"Sometimes just the process of evaluation is revealing, whatever the outcome. An unsatisfactory answer can still lead us to a better question."
Almstrum, et al (1996)

Abstract

The learning styles of a voluntary group of distance education students taking the Open University course *M206 Computing: An Object Oriented Approach* was determined via web based questionnaires and compared against measures of academic performance and *commencement-date,* a measure of how far in front or behind a student was of the expected date in the course calendar in starting the unit LB09. Significant relationships were noted between a number of learning styles and measures of academic performance. No significant results were found with *commencement-date*, however a potentially strong relationship was noted for future research. The study supports the need for continued research into the effect of learning styles on distance education course design.

Introduction

The research described here reports the findings of an exploratory study looking at the relationships between individuals' learning styles and their observed online behaviour. It follows from a series of studies using AESOP (see Chapter 2). The results of a concurrent study, identifying trends found in the learning styles of distance education students are discussed. Some of the latter work has already been published (Logan and Thomas, 2002b; 2002a), and is included here to support more recent findings.

The topic of individual differences in learning styles and the use of online material is fairly recent, tracing its history both from work on the benefits of using computers to provide online pedagogical material (Alessi and Trollip, 1991; Kulik and Kulik, 1991; Kulik, 1994; Sivin-Kachala, 1998; Bennett, 1999; Schacter, 1999) and tangential research into individual differences in learning and cognitive styles in education (Dunn and Dunn, 1978; Griggs, 1991b; Grasha, 1996b; Wilson, 1996; Montgomery and Grout, 1998; Valenta et al., 2001).

Individual differences in learning style are relevant because they can affect how well an individual interacts with pedagogical material. It has been found that teachers' and/or course designers' own preferences for the type and way that they deliver material must be taken into consideration because this can influence the effectiveness of pedagogical material, its delivery, and methods (Griggs, 1991a; Renniger et al., 1992; Wilson, 1996; Montgomery and Grout, 1998; Lang et al., 1999; Goold and Rimmer, 2000). Research has also shown that individuals can learn more effectively if the pedagogical material is matched to their specific learning style (Dunn and Dunn, 1978; Grasha, 1996b; Montgomery and Grout, 1998).

In the traditional classroom environment teachers have the opportunity to adapt and present material to meet the individual needs of students, but this is not as easy to accomplish in distance education environments where students may not have access to a tutor or, if they do, access is limited by the restrictions implicit to distance education. One way of compensating for the lack of contact with a personal tutor in distance learning has been to take advantage of multimedia developments and to generate pedagogical materials that are suitable for a range of learning styles. Nonetheless, such multimedia materials generally use a single pedagogical design that has several disadvantages including the following:

- students not having access to computers of sufficient specification to cope with the multimedia material (Logan and Thomas, 2001b);
- using the wrong combination of multimedia can be detrimental rather than beneficial to the acquisition of information (Mayer, 1997); and
- using multimedia that does not address all cognitive and learning style preferences, such as the Independent and Collaborative style discussed by Grasha (Grasha, 1996b).

With problems inherent in using a single multi-media approach and advantages to matching pedagogical material to individual cognitive and learning style preferences, this has led to several research issues be explored including the influences of learning styles on human-computer interaction in learning situations (Liu and Reed, 1994; Ross and Schulz, 1999; McWilliams, 2001), whether computer-based instruction could, or should, provide a more personal instructional experience (Osipova et al., 2001) and, in conjunction with this, the automatic adaptation of pedagogical software to provide a more personal instructional experience. The latter two issues are, at the time of writing, often a topic of discussion on pertinent internet discussion lists (see for example: Cristea, 2003; Sasikumar, 2003). The dissertation by Vicki McWilliams (2001) however, deserves further discussion, because of its relevance to the present work.

McWilliams uses a customised computer-based training program, along with measures of Kolb's Learning Cycle and the visual and verbal cognitive styles to investigate a number of hypotheses about how adult learners learn in a computer-based training environment in order to test out a number of relationships between learning styles and students' use of computer-based training. The computer-based training program, designed using Macromedia's Authorware program, was created to deliver a training course on holding an effective meeting at work. The program also recorded, to file, an 'audit trail' of a number of behaviour patterns such as the time a user took to complete the course, their final assessment score, the number of attempts to achieve the minimum score required, and whether they returned to previous pages, replayed the page they were on, or accessed the online help system.

Although McWilliams found no significant results, her work was based on several premises that, while justified, are contradicted by other research. One aspect is the use of total time taken to complete the work as a measure. This criticism is also applicable to other works which use the same measure (Liu and Reed, 1994; Ross and Schulz, 1999), and although it is possible that students in these studies worked on materials without breaks, the amount of time students spent focussed on the task as opposed to taking brakes does not appear to be accounted for. In work by Thomas and Paine (2000a), reported in Chapter 3, it was noted that distance education students using online material often took breaks, even when using materials for short periods, sometimes for long periods, making it difficult to ascertain how much time they had genuinely been spending working on the learning material. An alternative measure, Total Active Time (TAT) was developed which because of the nature of the audit trail being created in the AESOP research tool, allowed all breaks over 5 minutes to be excluded. Significant results have since been found using the TAT measure (Chapter 3).

To measure participants' preferences on Kolb's Learning Cycle and the visual-verbal cognitive style, McWilliams uses Kolb's Learning Style Inventory IIa [1993] and Kirby, Moore and Schofield's (1988) revised version of Richardson's (1977) Visual Verbal Questionnaire. In both measures McWilliams classifies participants according to their strongest preference and these preferences are regarded as being static. Honey and Mumford (1986; 1995), in contrast, who base their Learning Styles questionnaire on an adapted version of Kolb's Learning Cycle, state that they expect the four dimensions to be dynamic and individuals to be able to change and improve their abilities in each of the styles. Although the visual and verbal styles are a cognitive construct which some authors cite as having constant and stable characteristics (Richardson, 1977; Zenhausern, 1990), others perceive them as being mutable and able to shift gradually over time (Graham, 1997; Liu and Ginther, 1999). However, Kirby et al. (1988) found that college students had significantly higher scale scores than a sample from army personnel and that, the older the army personnel were, the lower the scale scores they achieved. The reason for this was put down to the observation that army personnel were no longer studying, implying that the visual and verbal constructs being measured are capable of changing.

Dynamism of learning styles is important because, although an individual may have a preferential way of learning at one point in the course, the pedagogy and media used to present the course can change an individual's preference for some styles. For measurements of cognitive and learning styles, this means that the point in time at which the measurement was made has to be taken into account. However from a pedagogical point of view, if a style is regarded as being static then the focus is on its stability over time and once the style is identified material can be matched to it. However if a style is regarded as being dynamic then the focus is on how it changes and course designers may even try to foster this change (Riding and Cheema, 1991).

An additional factor that may have had an effect on McWilliams' findings is her categorisation of participants into one single preferred dimension on each of the measures. It is however expected that participants can be of a similar strength in two or more dimensions (Honey and Mumford, 1986; Kirby et al., 1988; Honey and Mumford, 1995; Kozhevnikov et al., 2002) and this was not factored in her analyses.

Research Questions

This chapter sets out address the three research questions remaining that were originally asked in Chapter 1. The first question, of whether distance education students show a preference for the 'time of day' or 'day of the week' that they work - was considered in Chapter 3. Chapter 4 looked at whether the amount of comfort that a student expresses at the start of a course was related to their use of CBI material, while Chapters 6, 7 and 8 addressed the issue of whether distance education students had a greater preference for certain learning styles to the general population.

The remaining three research questions to be considered and addressed are:

4. **Is there a relationship between individual's preferences for selected learning styles and their use of CBI material?** The effectiveness of pedagogical material for an individual can be influenced by whether the material matches the learning style of the individual (Dunn and Dunn, 1978; Grasha, 1996b; Montgomery and Grout, 1998), but the question remains as to whether this can be observed in the way an individual uses the material.

5. **Do any of the factors of learning style, time or comfort relate to students' ability to learn as measured by their academic performance or time to complete tasks?** That is, what is the practical/realistic value of the factors? Schlechter (1991), cited by Ross and Schulz (1999), argues that effective computer-aided instruction can compensate for teachers' inability to meet the needs of all learners, but as Ross and Schulz found, not all learning styles benefit from computer-aided instruction and it can be detrimental (Ross and Schulz, 1999). In addition, people can and do adapt to a single source of information, for example most people can learn directly from a text book, with a greater or lesser degree of

success. The answer therefore is in the identification of those learning styles which have a significant influence on performance measures of concern to the provider or learner. Performance measures could include, exam score, improved long term retention of the material, more accurate recall, and shorter learning terms, among others.

6. **If any factors are found to affect the use of CBI and noted to significantly affect a student's performance, is it possible to identify these factors/styles automatically and therefore for software to be automatically adaptive to meet individuals' needs?** Or, in order for pedagogical software to be able to determine automatically an individual's learning style, a learning style needs to be identified that has a consistent recognisable pattern of behaviour that is definitive enough to be distinguishable by software.

In earlier work with AESOP investigating how students worked in relation to time, patterns were noted in the way students behaved online (Chapter 3, see also Thomas and Paine (2000b) and Logan and Thomas (2001b)) and identified the use of the Total Active Time as a closer approximation of the actual time students spent studying. The intention of this study therefore is to use AESOP to investigate in more detail individuals' online behaviours and how these relate to the learning styles chosen for this study in Chapter 5, and also address the relevance of the behaviours and learning styles by looking at their relationship with academic performance.

Research Outline

As it is necessary to investigate both learning styles and online behaviour together the method chosen was to repeat the earlier (2000) AESOP study, with the addition of the learning style questionnaires discussed in Chapter 5. The following series of analyses using the same source of data were then carried out to address the individual research questions.

<u>Study 1:</u>

Comparison of the learning style preferences of M206 students with other distance education students.

This is a series of analyses that were carried out to compare participants' preferences for the selected learning styles against the expected preferences of other distance education students already determined in Chapters 6 - 8.

<u>Study 2:</u>

Identification of behavioural traits.

Comparison of learning styles with time taken to complete LearningBooks.

The above series of analyses identify and define the behavioural traits being studied and then address Research Question 4, of whether there is a relationship between distance education students' individual preferences for selected learning styles and their use of CBI material.

<u>Study 3:</u>

Comparison of learning styles with academic performance

Comparison of commencement-date with academic performance

These analyses address Research Question 5, and assesses the practical/realistic value of each of the factors.

Research Question 6, looking at the practicality of having pedagogic software that is automatically adaptive to an individual's needs, uses the data from both Study 2 and Study 3 and is addressed in the Discussion.

Method

The Questionnaires

There are a number of potential cognitive and learning styles that could have interactions with performance, but it is impractical to examine every learning style at the same time. After a review of the literature, three learning style questionnaires were chosen which were considered the most relevant to the distance education learning environment, as well covering a broad range of different aspects in the field of cognitive and learning styles. These are, Honey and Mumford's Learning Style Questionnaire (*Activist*, *Reflector*, *Theorist* and *Pragmatist* styles) (Honey and Mumford, 1986; 1995), the Grasha-Riechmann Student Learning Styles Scales (*Independent*, *Avoidant*, *Collaborative*, *Dependent* and *Participant* styles) (Riechmann and Grasha, 1974; Grasha, 1996b) and an English version of Antonietti and Giorgetti's Questionnaire of Visual and Verbal Strategies (*Visual* and *Verbal* styles) (Chapter 8). Honey and Mumford's Learning Style Questionnaire and the Grasha-Riechmann Student Learning Styles Scales are reviewed in Chapter 5.

Computing General Demographic Questionnaire

In addition to the three learning style questionnaires a forth questionnaire, the Computing General Demographic Questionnaire (CGDQ), was included. The CGDQ was reviewed in Chapter 3.

All four questionnaires were distributed in electronic form that were completed by participants online via a webpage. Data was collected on a centralised database and processed manually to meet the requirements of the copyright holders for the Honey and Mumford Learning Styles Questionnaire.

Use of Normative data for Distance Education Students

As the results of this study are a reflection of distance education students use of CBI, a more meaningful comparison group is needed to compare the results against rather than the general population, particularly as it has been shown in Chapter 6 that the preferences of distance education students for the learning styles being used are different from the general population. Because of this, the normative data for Open University distance education students was used (Chapters 6, 7 and 8), instead of the norms given for the general public.

Participants

All students (N = 4578) studying the 2001 presentation of the Open University's distance learning course *M206 Computing: An Object Oriented Approach*, were invited to participate in the study at the commencement of the course through a message posted on the course's web-based notice board at the end of January (the Open University academic year runs from February to September). Those who were interested were directed by hyperlink to the Computing General Demographic Questionnaire (CGDQ). Students who completed this questionnaire (N = 66) were then directed by hyperlink to the location of the three online learning style questionnaires, and the AESOP recording tool software for downloading. No incentives other than explaining the aims of the study were used.

46 students completed the learning style questionnaires at the start of the study; of these, 23 (50%) returned recordings for analysis (17 post-study).

Collection of AESOP Data

Students wishing to participate in the study were invited to download the AESOP recorder and install it onto the computer used for studying the course material.

During the programming part of the course, participants were frequently reminded to send their recordings in as e-mail attachments. Files could be sent compressed in a ZIP format if participants were concerned about file size. In late July, to avoid disruption to preparations for the end of course exams and making allowances for the possibility that many would be taking summer holidays, participants were asked to e-mail in any remaining recordings.

Results

66 students completed the pre-study CGDQ, of which 46 (21 females, 25 males) continued on to complete the learning styles questionnaires and send in recordings.

Being an exploratory study, there was no predetermined underlying statistical technique around which the research was designed. However, the small number of participants and resultant small data sets limits the type of analyses available. Data was therefore explored first using parametric and non-parametric techniques, appropriate to the available data, to identify general trends. Those trends subsequently identified were then analysed in finer detail. For these, non-parametric techniques of Mann-Whitney and Kruskal-Wallis have been used in preference to statistically stronger parametric techniques such as one-way analysis of variance, as they are not dependent on the assumption that comparison groups have equal variance.

Participant Demographics

As a way of gauging how representative the participant sample was compared to the M206 course population the age and gender demographics of the sample were compared against the demographics of the total course population for 2001. Details of the distribution frequencies found for both the sample who answered the learning style questionnaires and the sub-set of these who submitted records are given in Table 9.1 and Table 9.2.

	Course Population (N = 4578)	Learning Styles Questionnaires (n = 46)	Submitted Recordings (n = 23)
Male	76.3%	54.3%	63.6%
Female	23.7%	45.7%	36.7%

Table 9.1: Comparison between course population and participant distribution by gender.

	Course Population (N = 4578)	Learning Styles Questionnaires (n = 46)	Submitted Recordings (n = 23)
Under 25	10.8%	4.35%	9.1%
25 - 29	19.2%	19.6%	13.6%
30 - 39	42.8%	41.3%	50.0%
40 - 49	20.2%	30.4%	22.7%
50 - 59	5.7%	4.3%	4.5%
60 - 65	0.7%	-	-
Over 65	0.7%	-	-

Table 9.2: Comparison between course population and participant distribution by age range.

It can be seen from Table 9.1 that the sample of students who completed the learning style questionnaires and those who continued on to submit recordings had in both cases a greater proportion of females than the course population. This was found to be statistically significant for those who completed the learning style questionnaires (χ^2 = 12.25, 1 df, p = 0.0004) but not for those who continued to submit recordings (χ^2 = 1.95, 1 df, p = 0.163) indicating that the participating sample who completed the learning style questionnaires was not representative of the M206 population with regard to gender, but those who carried on to submit recordings were a representative sample.

From Table 9.2 is can be seen that those who completed the learning style questionnaires and those who continued on to submit recordings have distributions that reflect the course population. Those who completed the learning style questionnaires were noted to be slightly older particularly in the 40-49 age range, but this was not found to be significant ($\chi^2 = 4.98$, 6 df, $p = 0.548$). There was also no significant difference noted with those who continued onto submit recordings ($\chi^2 = 4.99$, 6 df, $p = 0.545$), indicating that the participating sample was representative of the ages taking part in the course population.

Study 1 results

Comparison of the learning style preferences of M206 Students with other distance education students.

A consideration that needs to be taken into account when examining the learning style preferences of the M206 student participants is whether they differ in their levels of preference from other distance education students. A frequency table comparing the learning style preferences of M206 students against the gender specific norms of other Open University distance education students (OUDES) is given in the Tables 9.1, 9.2 and 9.3.

Comparisons with the expected distribution frequencies for each style using chi-square found that participants were only significantly different from the OUDES population on the *Pragmatist* style ($\chi^2_{\text{Pearson}} = 15.48$, 4 df, $p = 0.0038$) and *Avoidant* style ($\chi^2_{\text{Pearson}} = 14.41$, 4 df, $p = 0.006$).

Preference	Activist	Reflector	Theorist	Pragmatist
Very Low	8	7	3	11
Low	9	13	15	4
Moderate	21	19	18	11
High	5	5	5	14
Very High	2	1	3	5
Total	**45**	**45**	**44**	**45**

Table 9.3: Frequency count of participants' levels of preference for Honey and Mumford's Learning Style Questionnaire, using Open University distance education student norms.

Preference	Independent	Avoidant	Collaborative	Dependent	Participant
Very Low	5	9	5	7	4
Low	7	15	11	11	4
Moderate	19	11	19	20	20
High	8	7	7	5	13
Very High	5	2	2	1	3
Total	**44**	**44**	**44**	**44**	**44**

Table 9.4: Frequency count of participants' levels of preference for Grasha and Reichmann's Student Learning Styles Scales, using Open University distance education student norms.

Preference	Visual	Verbal
Very Low	7	8
Low	6	5
Moderate	12	20
High	11	7
Very High	8	4
Total	**44**	**44**

Table 9.5: Frequency count of participants' levels of preference for Visual and Verbal styles, using Open University distance education student norms.

For the *Pragmatist* style (Figure 9.1) participants were noted to have two peaks, one by the group expressing a 'very low' preference and another by the group expressing a 'high' preference.

Further examination of the data showed that the majority of those who expressed a very low preference for the pragmatist style were males (9 males, 2 females), but subsequent analysis found no significant differences in the distributions between the genders ($\chi^2_{\text{Pearson}} = 4.979$, 4 df, $p = 0.289$).

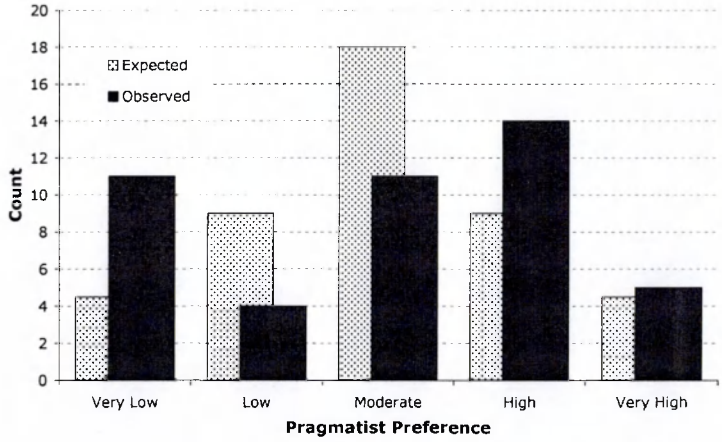


Figure 9.1: Participants' observed preference for the Pragmatist style on Honey and Mumford's Learning Styles Questionnaire compared to other distance education students.

The other significant difference was with the *Avoidant* style (Figure 9.2) in which participants were noted to be less avoidant than other distance education students.

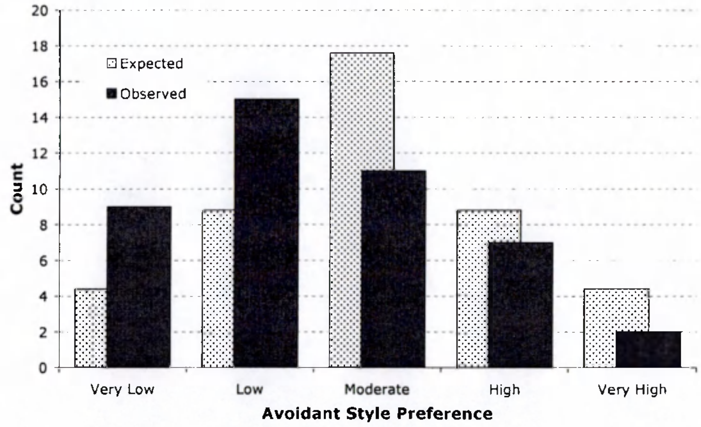


Figure 9.2: Participants' observed preference for the Avoidant style on The Grasha and Riechmann Student Learning Style Scales compared to other distance education students.

The implications of these findings are considered further in the Discussion.

Study 2 results

Identification of behavioural trends

This series of analyses focuses on identifying behavioural trends or *patterns of learning* (Liu and Reed, 1994) in the way that participants were found to use the online practical material, and also investigates whether the identified behaviours have an underlying specific learning style.

Another behavioural trait involving time identified in this study, *commencement-date*, takes into account the difference in time (in days) between when a student starts working on the LB and the date they were expected to start working on the LB. This is more of a scale measure rather than an ordinal or nominal categorical trait, but it apparently has not been considered by other researchers, possibly because it is only really associated with courses that have a study calendar, as is the case for the majority of courses provided by the Open University.

The study calendar for the M206 course identifies the course text and therefore the relevant LBs, which are recommended to be studied in each week of the course. Students do not have to keep to the study calendar, except for completion of TMAs and watching a recording of the terrestrial television broadcasts related to the course. Earlier studies have found (Chapter 3) that there is fair amount of variability in when students start working on the LBs.

Because *commencement-date* is a distinctive behaviour it was felt worthwhile to look for a possible link between *commencement-date* and learning styles. It was also decided to investigate the relationship of this behaviour with academic performance since if a relationship was found, then this behaviour could be monitored and used by software to provide a better learning experience.

LB09 and LB12 were selected for analyses, as their material involved some programming, but remained sufficiently structured to provide a common set of tasks requiring set responses. In later LBs students have greater choice in the possible solutions to the task and this variability could affect the time it takes to complete the task. An individual therefore, may choose a more circumlocutory method to solve a task over a more direct one; this could be because they are unaware of the more direct method or choose the longer method as a matter of personal choice amongst other reasons.

Study 2: Comparison of commencement-date with learning style preferences.

The range of *commencement-dates* by participants for LB09 varied from 21 days in advance to 12 days after the expected date scheduled in the course calendar. The range of *commencement-dates* for LB12 by participants varied from 14 days in advance to 17 days after. Table 9.6 details the distribution, categorised according to the number of weeks students were in advance or behind with their *commencement-date*,

Weeks in advance of expected commencement-date	LearningBook 09 Number of participants	LearningBook 12 Number of participants
2	5	1
1	3	2
0	2	8
-1	1	3
-2	-	1
Total	**11**	**15**

Table 9.6: Frequency table showing students' starting date for working on a Learning Book compared with expected date..

Considering that LB09 and LB12 are only one week apart on the M206 study calendar (LB09 in week 5, LB12 in week 6), it is interesting to note the shift in distribution from participants being generally in advance of the expected *commencement-date* for LB09 to being much more evenly distributed around the *commencement-date* for LB12. Although there is a general trend for individuals to fall behind, two participants were noted to improve on their *commencement-dates*, including the single participant who started LB09 after the *commencement-date*.

Further investigation into the relationship between starting date, learning style preferences and measures of academic achievement were not felt worthwhile after taking into account the small numbers and variability of the data even within this small space of time. The potential of *commencement-date* being a useful measurable behavioural trait remains an item for further work.

Study 2: Comparison of learning styles with time taken to complete LearningBooks.

Research by other authors looking at time taken to complete computer based instructional tasks have looked at the total time to complete the online work, but not taken into account, or been unable to measure, the amount of time individuals have spent not working on the task (Liu and Reed, 1994; Ross and Schulz, 1999; McWilliams, 2001). As mentioned in the introduction it has already been noted (Thomas and Paine, 2000a) that students were found to take breaks from their work and, if this is taken into account, a measure of the *Total Active Time* (TAT) can be derived. TAT is defined here as the total amount of time a student has spent actively working on the material, excluding any breaks exceeding five minutes or more. This has already been shown in Chapter 3 to be a more useful measure of student activity than using the total time taken to complete a task and used here for this reason.

Participants' learning style raw scores were analysed against the TATs taken to complete LBs 09, 10, 12, 13, 14 and 15 using Pearson's correlations (Table 9.7). The LBs chosen for analysis were those occurring midway through the course where students are beyond the basics and are starting to program, but structured so that there is less opportunity for individual variation in the choices taken by students to complete set tasks.

		LB09 TAT	LB10 TAT	LB12 TAT	LB13 TAT	LB14 TAT	LB15 TAT
		N = 12	N = 18	N = 20	N = 19	N = 18	N = 18
Activist	r_p	0.166	0.251	0.136	-0.031	0.218	-0.304
	Sig.	*0.606*	*0.316*	*0.567*	*0.900*	*0.385*	*0.220*
Reflector	r_p	0.209	0.040	0.066	0.020	0.205	-0.127
	Sig.	*0.515*	*0.874*	*0.783*	*0.936*	*0.415*	*0.615*
Theorist	r_p	-0.299	-0.304	-0.095	**-0.610**	0.012	**-0.529**
	Sig.	*0.345*	*0.220*	*0.689*	*0.006*	*0.961*	*0.024*
Pragmatist	r_p	-0.058	-0.140	0.183	**-0.467**	-0.076	**-0.483**
	Sig.	*0.858*	*0.579*	*0.439*	*0.044*	*0.764*	*0.042*
Independent	r_p	-0.023	-0.102	0.163	-0.450	0.189	-0.343
	Sig.	*0.943*	*0.687*	*0.493*	*0.053*	*0.453*	*0.163*
Avoidant	r_p	-0.102	0.022	-0.083	0.047	0.028	0.199
	Sig.	*0.753*	*0.932*	*0.728*	*0.848*	*0.913*	*0.427*
Collaborative	r_p	0.556	0.214	**0.499**	0.244	0.191	0.027
	Sig.	*0.060*	*0.394*	*0.025*	*0.314*	*0.448*	*0.914*
Dependent	r_p	-0.233	-0.297	0.068	0.180	-0.154	**0.509**
	Sig.	*0.467*	*0.231*	*0.775*	*0.461*	*0.541*	*0.031*
Participant	r_p	0.186	-0.082	**0.525**	-0.086	0.050	0.095
	Sig.	*0.562*	*0.747*	*0.017*	*0.727*	*0.844*	*0.707*
Visual	r_p	0.514	0.286	**0.497**	0.204	0.390	0.020
	Sig.	*0.087*	*0.249*	*0.026*	*0.402*	*0.109*	*0.938*
Verbal	r_p	0.568	0.153	0.199	-0.064	0.216	-0.008
	Sig.	*0.054*	*0.544*	*0.400*	*0.794*	*0.390*	*0.976*

Table 9.7 : Detailing the Pearson correlations and significance levels, between participants' learning styles raw scores and Total Active Time taken to complete various Learning Books. Significant results are highlighted in ***bold*** *type*

Scores on both the *Theorist* and *Pragmatist* styles were found to have significant, negative correlations with the TAT taken to complete LB13 (Theorist r_p = -0.610, p = 0.006; Pragmatist r_p = -0.467, p = 0.044) and LB15 (Theorist r_p = -0.529, p = 0.024; Pragmatist r_p = -0.483, p = 0.042). Closer inspection of the *Theorist* data (Figure 9.3) shows a single outlier that significantly affects the analysis of LB15, and if excluded, the correlation between the TAT taken to complete LB15 and the pre-study *Theorist* style score is no longer significant. The outlier, however, does not significantly affect the correlation between the TAT for LB15 and the *Pragmatist* style score (Figure 9.4).

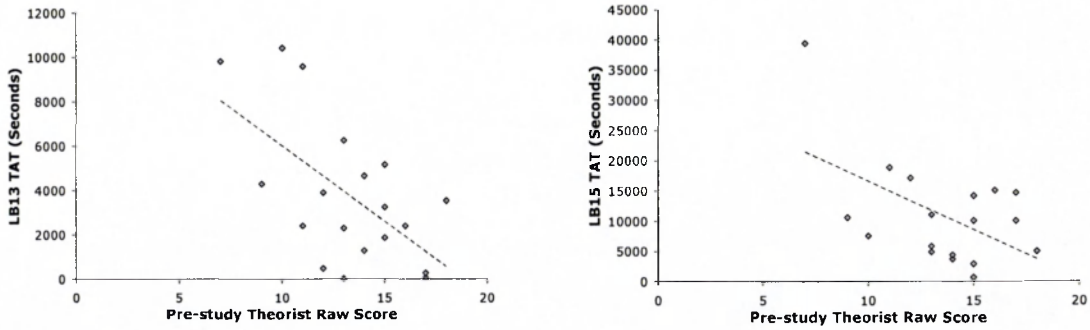


Figure 9.3: Scatter plot detailing statistically significant relationships between the Theorist learning style and LearningBook TATs.

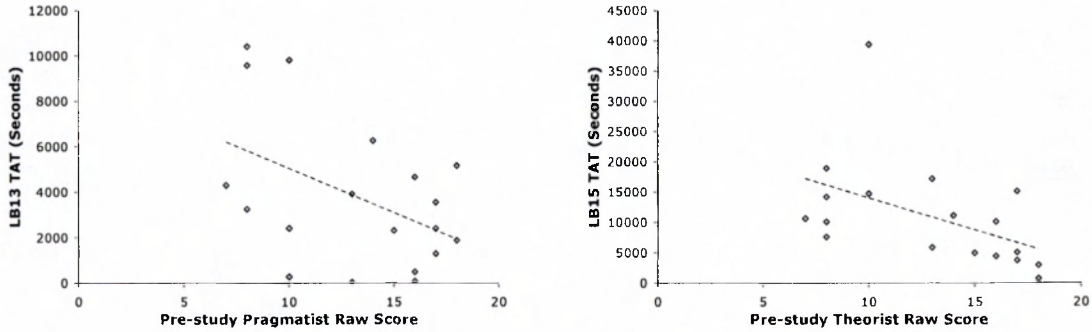


Figure 9.4: Scatter plot detailing statistically significant relationships between the Pragmatist learning style and LearningBook TATs

The presence of the outlier has been left however, as Kulik (1994) comments that although some analysts feel that unusually high of low values should be eliminated from distribution, others believe extraordinary results should be left and merit careful scrutiny because they "provide valuable clues about improving instructional materials."

A Spearman correlation analysis of the relationship between *Theorist* and *Pragmatist* styles using the normalised scores found a statistically significant positive relationship between the two ($r_s = 0.423$, $p = 0.004$) indicating that participants who had a strong preference for the *Theorist* style also had a strong preference for the *Pragmatist* style and this would account for the similarity between the *Theorist* and *Pragmatist* styles.

The *Collaborative, Participant* and *Visual* style scores were also all noted as having significant positive correlations with LB12 (Table 9.7). The *Dependent* style was also noted to have a significant positive correlation with the TAT for LB15 (Table 9.7). The implications of these findings are considered later, in the discussion.

Because of the similarity of results between the *Collaborative*, *Participant* and *Visual* styles, implying a possible link, the normalised data for all three were compared with each other using Spearman's correlation. The results of this are given in Table 9.8.

Pre-study norm score (OUDES)		Collaborative (N = 46)	Participant (N = 46)	Visual (N = 44)
Collaborative (N = 46)	r_s		**0.382**	0.095
	Sig.		*0.009*	*0.541*
Participant (N = 46)	r_s	**0.382**		0.152
	Sig.	*0.009*		*0.324*
Visual (N = 44)	r_s	0.095	0.152	
	Sig.	*0.541*	*0.324*	

*Table 9.8: Details of Spearman correlation analyses between the pre-study preferences for the Collaborative, Participant and Visual styles. Significant correlations are highlighted in **bold** type.*

Only the *Collaborative* and *Participant* styles are noted to be significantly correlated with each other implying that individuals who had a preference for being *Collaborative* also had a preference for being *Participant* and this would account to some extent for the similar correlations found for the TATs in LB12. Preference for the *Visual* and *Collaborative* styles were not noted to be correlated and therefore it can be presumed that these style are independent of each other.

Study 3 results

Comparison of learning styles with academic performance

Academic achievement at the Open University for M206 students can be measured in several ways. Students are given a conventional written exam at the end of the course providing an Overall Exam Score (OES) and also have continuous assessment of their work through Tutor Marked Assignments (TMAs). TMAs are pieces of practical work set at certain points during the course that are marked by the tutor responsible for the individual. TMA scores also count towards the final grade given to the students, known as the Overall Continuous Assessment Score (OCAS). Both the OES and OCAS scores were obtained from university records.

Because some individuals can be significantly better at exams or vice versa with practical work, a third measure, Exam-Assessment Difference (EA_{Diff}) was calculated by subtracting the OES from the OCAS.

$$EA_{Diff} = OCAS - OES$$

Pearson correlations were used to identify trends between individuals' raw scores on the learning style scales and their academic achievement on the M206 (Table 9.9). Data was also filtered to exclude from analysis those students who scored zero in the exam or who submitted less then five TMAs out of the seven that are set for the course.

The *Avoidant* style also had a small, negative, statistically significant correlation with both the OES ($r_p = -0.355$, $p = 0.025$) and the OCAS ($r_p = -0.336$, $p = 0.034$), such that participants with higher scores on the *Avoidant* scale generally had lower OES and OCAS scores. Further analysis using a Kruskal-Wallis comparison on the revised five point normative data from the OUDES (Chapter 7) found that the scores on the OES were significantly different between participants' levels of preference ($\chi^2 = 9.895$, $p = 0.042$) but not between groups for OCAS ($\chi^2 = 8.420$, $p = 0.077$), although this was just outside the 95% level of confidence. This confirms the relationship that the higher the level of participants' preference for being *Avoidant* the lower their academic performance.

Pre-study raw score		Overall Exam Score	Overall Continuous Assessment Score	Diff between OCAS and OES (EA_{Diff})
Activist (N = 39)	r_p	-0.307	-0.302	0.180
	Sig.	*0.057*	*0.061*	*0.273*
Reflector (N = 39)	r_p	0.022	-0.017	-0.062
	Sig.	*0.893*	*0.919*	*0.706*
Theorist (N = 39)	r_p	-0.005	-0.002	0.007
	Sig.	*0.974*	*0.990*	*0.965*
Pragmatist (N = 39)	r_p	-0.193	-0.242	0.047
	Sig.	*0.239*	*0.137*	*0.777*
Independent (N = 40)	r_p	0.119	0.048	-0.155
	Sig.	*0.464*	*0.767*	*0.339*
Avoidant (N = 40)	r_p	**-0.355**	**-0.336**	0.225
	Sig.	*0.025*	*0.034*	*0.164*
Collaborative (N = 40)	r_p	-0.238	-0.077	**0.334**
	Sig.	*0.139*	*0.637*	*0.035*
Dependent (N = 40)	r_p	**-0.353**	-0.295	0.273
	Sig.	*0.025*	*0.065*	*0.088*
Participant (N = 40)	r_p	-0.079	0.042	0.195
	Sig.	*0.626*	*0.798*	*0.229*
Visual (revised) (N = 38)	r_p	0.004	0.056	0.059
	Sig.	*0.979*	*0.740*	*0.726*
Verbal (revised) (N = 38)	r_p	-0.077	0.095	0.246
	Sig.	*0.647*	*0.569*	*0.137*

Table 9.9: Detailing the Pearson correlations and significance levels between participants' learning styles raw scores and their academic performance. Significant results are highlighted in ***bold*** *type.*

A significant, negative correlation was also found between the Dependent style and the OES (r_p = -0.353, p = 0.025). The correlation with the OCAS was also negative, but just outside significance (r_p = -0.295, p = 0.065). Kruskal-Wallis analysis of the revised five point normative data from the OUDES found no differences between the different levels of preferences on either the OES (χ^2 = 5.973, p = 0.201) or the OCAS (χ^2 = 4.142, p = 0.387).

A significant positive correlation was also noted between the *Collaborative* style and the Exam Assessment Difference (EA_{Diff}) (r_p = 0.334, p = 0.035). This is shown graphically in Figure 9.5. Further analysis using an independent t-test comparing collaborative raw score means between the positive and negative values of EA_{Diff} was also found to be significant (equal variances assumed, t = -2.353, p = 0.024).

Of interest is a small, but not statistically significant, negative correlation between the *Activist* style and both the OES (r_p = -0.307, p = 0.057) and OCAS (r_p = -0.302, p = 0.061). Further analysis using a Kruskal-Wallis comparison on the normative data from the OUDES for the Activist style also shows this not to be significant between the scores for the OES (χ^2 = 8.016, p = 0.091) and OCAS (χ^2 = 6.809, p = 0.146).

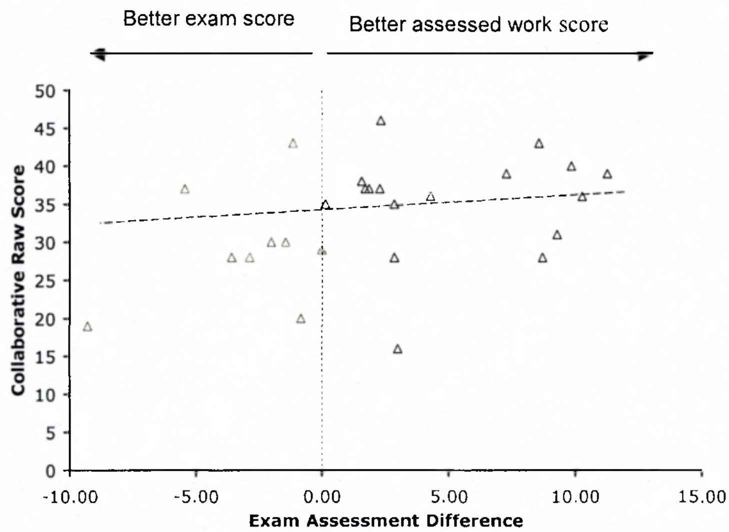


Figure 9.5: Scatter graph showing distribution of Collaborative Raw Scores in comparison to the Exam Assessment Difference.

Discussion

The aim of the research in this chapter was to address the following three research questions,

4. Is there a relationship between individuals' preferences for selected learning styles and their use of CBI material?

5. Do any of the factors of learning style, time or confidence relate to students' ability to learn as measured by their academic performance or time to complete tasks?

6. If any factors are found to affect the use of CBI and noted to significantly affect a student's performance, is it possible to identify these factors/styles automatically and therefore for software to be automatically adaptive to meet individuals' needs?

The study used an exploratory approach to look at three specific learning styles and behavioural data available from AESOP, rather than a hypothetico-deductive one because of the freedom it provides in finding potential relationships, an approach supported by Almstrum et al (1996).

Participants

66 participants completed the pre-study questionnaire in this study, in comparison to 345 in a previous similar study. It is uncertain why fewer students volunteered to take part, as the same method of student recruitment was used in both studies and the total number of students starting the M206 course was comparable. The previous study did not include the learning style questionnaires and it has been noted that the more questions, or questionnaires, participants are asked to complete the more laborious participants find it and therefore a lower response rate (Tuckman, 1978; Labaw, 1982). However, it is felt that inclusion of the learning style questionnaires was not a major factor affecting participation, as far fewer participants completed the pre-study Computing General Demographic Questionnaire than the previous year, and this was presented before participants were invited to go on to the learning style questionnaires.

The small number of participants and recordings means that the results are not as robust as desired. The results are useful data and add to the accumulating knowledge in the field as well as the generation of more specific research questions.

Study 1 discussion

Comparison of the iearning style preferences of M206 students with other distance education students.

It was noted earlier that the participating sample who took the learning styles questionnaires and continued on to submit recordings was representative of the 2001 M206 course population with regard to age and gender. The only anomaly was the finding of a significantly greater proportion of females in the participating sample that completed the learning styles questionnaires, although the proportion of these females that continued on to submit recordings dropped. This reflects the finding of studies such as Novo et al. (1999) who also found that females are more prepared to take part in questionnaires than males. However, the fact that fewer females than males went on to send in recordings is felt to be a reflection of the research in Chapter 4 and by others such as Shashaani (1994) and Busch (1995) which shows females to be less confident than males with computing related tasks and therefore less confident about the process of installing the AESOP recorder, retrieving files and emailing them.

In general there were few differences between participants and other distance education students in the learning styles measured. The significant differences that were found were on the *Pragmatist* scale of Honey and Mumford's Learning Styles Questionnaire, and the *Avoidant* style of the Grasha and Riechmann Student Learning Style Scale.

Participants' preferences for the *Pragmatist* style were divided between one group expressing a 'very low' preference for the style and a more general trend towards a greater preference for the style than other distance education students. Male subjects were noted to make up the majority of those expressing 'very low' preference for the style.

In the normative data study (Chapter 7), male distance education students were also found to be significantly different in their levels of preferences to females, so participants' scores in this study were normalised according to their gender as well. Therefore the finding is that there is a sub-group of males taking the M206 course who are much less pragmatic than other male distance education students. Honey and Mumford encourage users of the Learning Style Questionnaire to improve in those styles users have a lower preference for in order to become more rounded learners (Honey and Mumford, 1995). On this basis it might be suggested that those students who express a significantly lower preference for pragmatism could, if identified, be offered material to help improve their style. However, the data comparing the *Pragmatist* style with academic performance (Table 9.9) suggests that improvement of this style does not offer any significant academic advantages.

Participants were also found to have a significantly lower preference for being *Avoidant* than other students taking distance education courses at the Open University. One possibility is that those volunteering to take part in this study and complete the questionnaires are by their nature less *Avoidant* as by definition, those who are *Avoidant* are not enthusiastic about learning the content or participating with others. However this argument does not hold when it is considered that the participants in this study are being compared against the Open University norms obtained in Chapter 6 where the normative sample is also made of students who volunteered to take part.

Open University students have elected to take a distance education course and also paid course fees, and so it could be presumed that participants would be less avoidant. However, when the OUDES norms were being developed (Chapter 6) it was noted that Open University students were more avoidant than the general population. It is unclear what the significance of this finding is, but it deserves more detailed investigation.

Study 2 discussion

Comparison of learning styles with time taken to complete LearningBooks

Significant correlations were noted between a number of learning styles and the *total active time* (TAT) to complete a LearningBook (LB). However, the number of data points need to be considered when interpreting the significance and therefore meaning of the results.

Theorist and *Pragmatist* styles were both noted to have significant, negative correlations with the TAT for LB13 and LB15. This is rather contrary to expectations as the tasks of these LBs are more unstructured with open ended solutions - an attribute which Honey and Mumford comment does not suit those with a *Theorist* style. The LBs also have no clear guidelines on how to achieve the task, an attribute which is also negatively associated with those with a *Pragmatist* style (Honey and Mumford, 1995). There therefore must be other reasons for why LB13 and LB15 are quicker to complete for those with stronger *Theorist* and *Pragmatist* preferences. One consideration is that because these LBs are less structured and there are no clear guidelines, students with a preference for the *Theorist* and *Pragmatist* styles may decide to spend less time using these materials.

The TAT for LB12 was noted to have significant, positive correlations with the *Collaborative*, *Participant* and *Visual* learning styles. This was also partially reflected in the TAT for LB09 for the *Collaborative* and *Visual* styles, although both these correlations were just outside the 95% level of confidence. *Collaborative* and *Participant* styles were also noted to be significantly correlated with each other suggesting that individuals who had a greater preference for being *Collaborative* also had a greater preference for being *Participative* and this would, to some extent, account for the similarity between the two TAT correlations. *Visual* style was not noted to correlate with either the *Collaborative* or *Participative* styles and therefore must correlate with LB12 for a different reason.

LB12 is one of the first chapters along with LB09 to involve structured material that does not use the Graphical User Interface (GUI), but allows students to enter statements directly into the workspace. This would support the finding that students who have a greater preference for being *Participative* take longer to complete the material because *Participative* students are described by Grasha (1996b) as typically eager to do as much of the required and optional requirements of the course as possible and so are likely to spend more time carrying out the set exercises than others.

The move away from using the GUI is also supportive of the finding that students with a preference for the *Visual* style take longer, because when a statement is evaluated in the workspace, students get a typed verbal description of the object's behaviour, but to see this visually they would need to switch to the GUI of the workspace. It is expected that students with a preference for the visual style are more likely to want visual confirmation of the object's behaviour after evaluation and therefore take more time.

The presence of this interaction, between those with a visual style and use of the GUI, indicates that LearningWorks includes material which is suitable for both visual and verbal styles, but it adds support to the multimedia argument that visual and verbal material should be presented together in a co-ordinated way (Mousavi et al., 1995; Mayer, 1997). That is students should be able to see both the visual and verbal representations together at the same time.

Commencement-date, was identified and explored in this research as potential behavioural measure. The small number of individuals and level of variability precluded any detailed analysis, but some interesting observations were noted.

Commencement-date uses the study calendar of the Open University and the specific dates for when chapters are expected to be studied. The differences between the dates when students started to work on the chapters and the expected date for starting was used as measure of how much in advance or behind students were with their work at this stage. It is appreciated that there are factors that could influence this such as the difficulty of preceding chapters. However, LB09 and 12 are studied early on in the course (during weeks 5 and 6 on the study calendar) and the chapters prior to LB09 are mainly introductory explaining the LearningWorks interface. Because of this it was considered that the extent of earlier chapters influencing the behaviours being looked for would be minimal and that certain learning styles may be identifiable within students' behaviour. For example,

- Students found to start their work earlier might have a preference for the *Activist* style as these students want to 'have a go' and, given the opportunity to look at or work with the material in advance, will do so. Alternatively, students may have a preference for the *Reflector* style as those with this style like the opportunity to read/work in advance with the information to think about it (Honey and Mumford, 1995).

- Students found to follow the study calendar are more rigid in their approach which would not be consistent with the *Activist* style (Honey and Mumford, 1995).

There was considerable variability in the *commencement-date* both between individuals and also between the two LBs in which the behaviour was being observed. Students were generally seen to start working on the LB one or two weeks in advance for LB09, but for LB12 to fall behind and work either during the week expected or one or two weeks later (Figure 9.6).

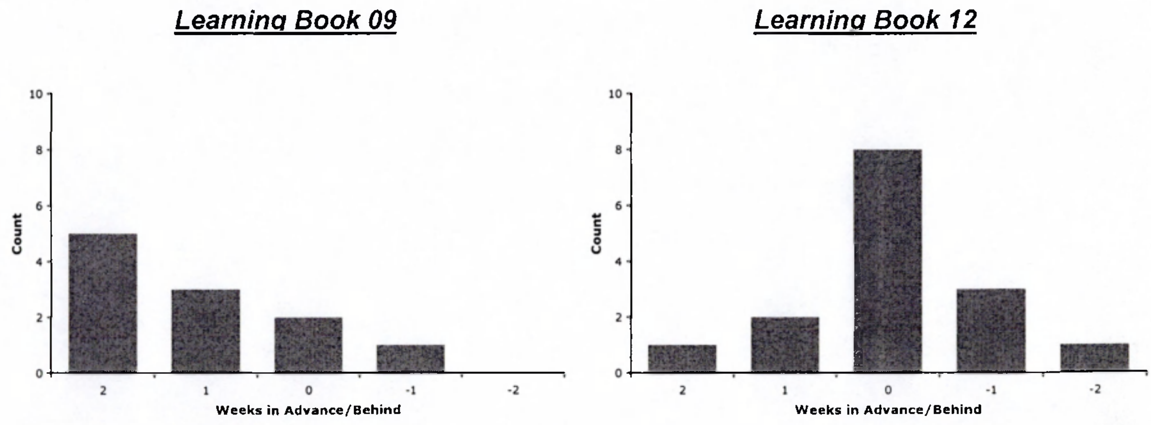


Figure 9.6: Frequency plot showing distributions of students' commencement dates for learning books in advance or behind of expected commencement date (in weeks).

This is an unexpected finding as LB12 is scheduled for the week (Week 6) following LB09 (Week 5). As participants' behaviour was not found to be constant between the two LBs, that is they did not have a *commencement-date* that was the same or similar in both LBs, further analyses looking at a consistent *commencement-date* was not considered useful, but reasons for why students fell behind at this point were investigated.

There was no direct data relating to individuals' lifestyles which could have caused students to fall behind. However, no public holidays in the United Kingdom were noted over this period in 2001, which if present could have accounted for students falling behind. It was also noted from the course calendar that students were expected to study LBs 10, 11 and 12 in the same week. Although earlier chapters such as LBs 06, 07 and 08 are also scheduled to be studied together in the same week (Week 4), most students were 2 weeks ahead of the expected date following these LBs, when they started LB09, that is within the space of two weeks most participants had covered LBs 01 – 08. The shift in the majority of participants from being ahead of the *commencement-date* by 2 weeks to the majority being on schedule at LB12 indicates that, for whatever reason, students slowed down and took longer to complete LBs than they did originally.

It has been noted anecdotally and in other studies (McWilliams, 2001) that students tend to ignore or rapidly progress through introductory material. The finding, that students generally commenced working on LB09 a week or two in advance supports this observation and has implications for the design of distance education courses as it suggests a shorter period should be given for introductory material, so greater time can be given to later work.

Further investigation of the data however, found that not all students in the sample fell behind with their *commencement date*. Those who did fall behind at this point appeared to be better at practical work than with examinations (Table 9.10).

Fell Behind	Mean OCAS	Mean OES	Mean EAdiff
No	85.82 (sd 11.36)	83.25 (sd 12.28)	2.57 (sd 3.41)
Yes	85.11 (sd 7.03)	73.00 (sd 12.31)	12.11 (sd 8.40)

Table 9.10: Comparison of mean scores and standard deviations between those noted to change commencement-date and fall behind and those who commencement-date remained the same.

Analysis using a Mann-Whitney test indicated that the difference between the OES means was not significant ($U = 6.000$, $p_{Exact} = 0.164$) and the difference between the mean EA_{diff} for each group was marginally outside the 95% level of confidence ($U = 4.000$, $p_{Exact} = 0.073$).

However, the potential of *commencement-date* as a behavioural trait, and also looking at those students who fall behind at a particular point in the CBI and the underlying cognitive reasons for it are worth exploring as it could be used to help distinguish one type of students from another.

The differences found between LBs in the distribution of *commencement-dates* also imply that students may benefit from only very short periods of time being given for introductory material to allow more time for later chapters.

Study 3 discussion

Comparison of learning styles with academic performance.

The relationship between individuals' learning style preferences and aspects of individuals' academic performance were analysed to give an indication of the relevancy of each learning style to distance education courses in general and more specifically the course *M206 Computing: An Object Oriented Approach.*

On the *Avoidant* style, there was a significant, negative correlation with both the OES and OCAS. That is the more *Avoidant* a student was the less they tended to score on the final exam and on TMAs. It is not surprising that those students who are *Avoidant* tend to do less well, but it is worth emphasising that the effect of preference for this style can seen in distance education students not just those attending traditional classroom settings. It also implies that this style should be considered when creating or improving course designs and that those who are identified as being *Avoidant* may need or would appreciate additional help to improve their overall academic performance.

The *Collaborative* style was also found to be related to academic achievement, such that individuals noted to have a higher preference for the style tended to do better at assessed work, but worse with examinations and vice versa. In the M206 course students have opportunities to, and are encouraged to, collaborate with each other. This supports

Grasha's description of individuals who are collaborative as those who typically feel they can learn by sharing ideas and skills, co-operating with the tutor and working with others (Grasha, 1996b). The relationship however needs further study as there is a certain amount of variance of the scores, but the *Collaborative* style does not appear to be a factor that has much affect on examination scores or assessed work.

Grasha defines those who have a preference for being *Dependent* as those who learn only what is required, and view their tutors and other students as sources for structure and support (Grasha, 1996b). Students who are *Dependent* therefore are likely to rely on others, but would be unable to do this during examination. This is supported in the research where it was noted that there was a significant negative correlation between preference for the style and exam performance. Further analysis using normalised scores for the *Dependent* style were not found to be significant. This could be due to a skewed preference for the style by participants such that very few students had a 'high' or 'very high' level of preference for being *Dependent* in comparison with the OUDES norms, indicating that although there is a correlation, this was not discernable at the grouping level used.

The *Activist* style also had a negative correlation with both the OES and OCAS academic measures, although both were just outside the 95% level of significance. This would seem to indicate the presence of a tendency for students with a stronger preference for the *Activist* style not to do so well in exams or assessed work and deserves further investigation, using a larger sample. That the Activist style is detrimental in distance education is mentioned by Honey and Mumford, who suggest that Activists learn less well in activities where the individual is required to engage in solitary work, such as reading, writing, thinking by themselves (Honey and Mumford, 1995).

It is worth noting that the presence of significant interactions between the learning styles looked at, TAT and academic performance also justifies their use in studies of distance education students. Both Honey and Mumford's Learning Style Questionnaire and the Questionnaire of Visual and Verbal Strategies measure learning and cognitive styles that apply to any learning situation, but the Grasha-Riechmann Student Learning Styles Scales although developed for the classroom can be seen to be just as applicable to distance education students.

Individualisation of software

A research question that has not been addressed directly so far is,

6. If any factors are found to affect the use of CBI and noted to significantly affect a student's performance, would it be possible to identify these factors/styles automatically and therefore for software to be automatically adaptive to meet individuals' needs?

The development of any software is expensive, therefore individualising CBI material needs to be of sufficient benefit to make the development of the courseware worthwhile. Thus a specific behaviour such as *commencement-date* or a learning style, may be identified in individuals' use of CBI material, but if they have no appreciable effect on how an individual learns the question arises whether there is a need to create extra or alternative material to meet these individual differences.

If a learning style or other factor is found to significantly affect an individual's academic performance, another question is whether to use direct or indirect methods to determine the individual's traits that are related to that factor. One solution is for software to determine directly the relevant traits, by including a questionnaire for an individual to complete at the start of the course and use the feedback from this to establish the best presentation method. However, if several traits are found, this could mean a substantial number of questions being asked. An alternative, and a focus of this research, is to determine whether those learning styles or factors noted to affect academic performance can be detected in individuals' online behaviour. This would allow software to automatically adapt its presentation to the specific needs of the individual or offer the individual the choice of taking the alternative presentation.

Support for the individualising of software in this research comes from the *Avoidant*, *Dependent*, *Collaborative* learning styles which were found to correlate with academic performance. Further, but unconfirmed, support comes from the finding that distance education students who fell behind between LB09 and LB12 appear to do worse in exams than other distance education students. The importance of this, if it is confirmed in future work, is that this behaviour is observable and easily monitored by the software on the machine the student is using.

Relationship with students' levels of comfort

It was found in Chapter 4 that students' levels of comfort with computing related tasks were also capable of affecting the TAT and academic performance. To take this factor into account the data was re-analysed to control for individuals' pre-study levels of comfort with programming and prior experience of programming, as these were the factors noted to have the most interactions with TAT and academic performance.

It was considered that those who did not fall behind between LB09 and LB12 may have had prior experience of programming, but a chi-square analysis comparing those who did or did not fall behind at this point with those with and without prior experience, showed that there was no interaction (χ^2 = .351, 1df, p = 0.554). The data also showed that prior experience of Open University courses was not a factor as only one student in the group analysed had no previous experience.

The original correlations carried out between learning styles and the TAT for LBs 09 – 15 were repeated, but partialling out the effect of comfort (Table 9.11). This procedure allows the linear relationship between two variables to be described while controlling for the effects one or more variables (*SPSS for Windows,* 2002).

N=22		LB09 TAT	LB10 TAT	LB12 TAT	LB13 TAT	LB14 TAT	LB15 TAT
Activist	r_p	0.310	0.454	0.301	0.003	0.456	-0.532
	Sig.	*0.455*	*0.258*	*0.469*	*0.994*	*0.280*	*0.175*
Reflector	rp	0.277	0.272	0.066	0.023	0.474	-0.275
	Sig.	*0.506*	*0.514*	*0.887*	*0.956*	*0.235*	*0.509*
Theorist	rp	-0.127	-0.181	-0.176	**-0.761**	0.203	-0.665
	Sig.	*0.765*	*0.668*	*0.677*	*0.028*	*0.630*	*0.072*
Pragmatist	rp	0.110	0.153	0.288	-0.532	0.222	-0.218
	Sig.	*0.796*	*0.717*	*0.489*	*0.175*	*0.597*	*0.605*
Independent	rp	0.145	0.063	0.237	-0.681	0.457	-0.439
	Sig.	*0.732*	*0.882*	*0.572*	*0.063*	*0.255*	*0.277*
Avoidant	rp	-0.169	-0.121	-0.178	-0.058	-0.367	0.164
	Sig.	*0.690*	*0.775*	*0.679*	*0.891*	*0.371*	*0.697*
Collaborative	rp	0.546	0.413	**0.773**	0.134	0.595	0.536
	Sig.	*0.161*	*0.309*	*0.025*	*0.752*	*0.120*	*0.171*
Dependent	rp	-0.426	-0.473	-0.097	0.404	-0.431	0.540
	Sig.	*0.293*	*0.236*	*0.819*	*0.321*	*0.286*	*0.167*
Participant	rp	-0.042	-0.241	0.441	-0.563	0.228	0.289
	Sig.	*0.992*	*0.565*	*0.275*	*0.146*	*0.588*	*0.488*
Visual	rp	0.476	0.457	**0.788**	-0.095	**0.778**	-0.134
	Sig.	*0.233*	*0.256*	*0.020*	*0.823*	*0.023*	*0.752*
Verbal	rp	0.605	0.518	0.678	-0.339	0.695	-0.0482
	Sig.	*0.112*	*0.189*	*0.064*	*0.411*	*0.056*	*0.910*

Table 9.11 : Details of partial correlations controlling for participants' pre-study levels of comfort with programming, between participants' learning styles raw scores and Total Active Time taken to complete various Learning Books. Significant results are highlighted in ***bold*** *type*

For the *Theorist* style the strength of the correlation with the TAT for LB13 improves from -0.610 to -0.761 although the level of significance falls to p = 0.028. However although the strength of the correlation with the TAT for LB15 also improves for the *Theorist* style this is no longer significant and just outside the 95% confidence level (p = 0.072). The *Pragmatist* scale on the other hand is no longer seen to correlate with either LB.

Correlation of the *Collaborative* and *Visual* style with LB12 also improves, the *Visual* style is also seen to significantly correlate with LB14.

As with the *Pragmatist* style the remaining original correlations seen in Table 9.7 are no longer found to be significant.

Although a number of the original interactions between learning styles and TAT disappear, the reinforcement of the *Theorist*, *Collaborative* and *Visual* learning styles emphasises the point that these styles have a relationship with individuals' use of CBI materials, but the nature of this relationship remains to be explored in further work.

The correlation between learning styles with academic performance was also repeated, controlling for (e.g. partialling out) the relationship of comfort with programming (Table 9.12). The results show that although *Avoidant* and *Collaborative* were no longer noted to have an effect on academic performance, the *Dependent* style is a significant factor affecting individuals' final mark. In addition the *Activist* style, noted to be just outside the level of significance originally, is now very significant with a strong correlation with the final examination mark. As with the analysis of learning styles with TAT, the results of this re-analysis emphasise that individuals' preferences for the *Dependent* and *Activist* learning styles have significant effects on their final academic performance.

It is worth noting as well, that these results reinforce the finding in Chapter 4 that the level of comfort with programming students have before the course can have an effect on both their use of CBI and academic performance. It would also appear that in some cases this is an interaction with other factors, such as with the *Activist* style.

N=22		OES	OCAS	EA_{diff}
Activist	r_p	**-0.430**	-0.101	**0.406**
	Sig.	*0.005*	*0.527*	*0.008*
Reflector	r_p	-0.137	0.112	0.186
	Sig.	*0.393*	*0.486*	*0.244*
Theorist	r_p	0.118	0.015	-0.117
	Sig.	*0.461*	*0.927*	*0.465*
Pragmatist	r_p	-0.222	-0.193	0.155
	Sig.	*0.164*	*0.229*	*0.333*
Independent	r_p	0.268	0.026	-0.269
	Sig.	*0.090*	*0.872*	*0.090*
Avoidant	r_p	-0.252	-0.234	0.171
	Sig.	*0.111*	*0.141*	*0.285*
Collaborative	r_p	-0.225	0.077	0.264
	Sig.	*0.158*	*0.634*	*0.096*
Dependent	r_p	**-0.390**	-0.108	**0.363**
	Sig.	*0.012*	*0.501*	*0.020*
Participant	r_p	0.102	0.051	0.009
	Sig.	*0.949*	*0.752*	*0.954*
Visual	r_p	0.094	0.075	-0.069
	Sig.	*0.559*	*0.643*	*0.670*
Verbal	r_p	0.177	0.069	-0.157
	Sig.	*0.268*	*0.669*	*0.327*

*Table 9.12 : Details of partial correlations controlling for participants' pre-study levels of comfort with programming, between participants' learning styles raw scores and academic performance measures. Significant results are highlighted in **bold type***

The presence of an interaction between the *Activist* style and comfort with programming suggests further work looking at the relationships between learning styles and these levels of comfort. The limited amount of data available at present however precludes a more detailed analysis of interactions between learning styles and levels of comfort on academic performance being undertaken.

Conclusion

The objective of the research was to use AESOP, an asynchronous, remote recording and playback tool, to explore three research questions.

- Is there a relationship between individual's preferences for selected learning styles and their use of CBI material?
- Do any of the factors of learning style, time and confidence relate to students' ability to learn as measured by their academic performance or time to complete tasks?
- If any factors are found to affect the use of CBI and noted to significantly affect a student's performance, is it possible to identify these factors/styles automatically and therefore for software to be automatically adaptive to meet individuals' needs?

Total Active Time (TAT), identified in prior research (Chapter 3) and *commencement-date* identified in this research were both used as behavioural measures of students' use of CBI materials. The learning styles investigated were those on Honey and Mumford's Learning Styles questionnaire, Grasha and Riechmann Student Learning Styles Scales and an English version of Antonietti and Giorgetti's Questionnaire of Visual and Verbal Strategies.

It was found that the TAT taken to complete a LB was related to individuals' preference for various learning styles. After controlling for students' levels of comfort (noted in Chapter 4 to affect the TAT), the *Theorist* style was noted to have a significant negative correlation with LB13 and a strong correlation with LB15, although this was just outside the 95% confidence level. *Collaborative* and *Visual* styles were also noted to have strong positive correlations with LB12 and the *Visual* style was also noted to correlate with LB14. Although these results are not consistent across all the LBs, possibly because of the changing nature of the LBs' content, a closer examination of the relationship that these learning styles have with other pedagogical material is needed before drawing a more definite conclusion, as it suggests a way that preferences for these styles can be determined in online behaviour. However, as several styles have been found to correlate with the TAT for the same LB, it would not be possible to use TAT by itself to identify preference for one style. Instead, it would have to be used in conjunction with other online behaviours to help identify a style. Nonetheless, this research shows another way that learning styles influence the use of CBI material.

The influence of learning styles on students' abilities to learn was measured by looking at learning style preference with various measures of academic performance. The *Activist* and *Dependent* learning styles were both found to have statistically significant correlations with measures of academic performance. The implication is that detection of individuals' levels of preference on these learning styles early on in the course would be an advantage in identifying those who would benefit from help with examinations or assessed work.

The overall findings suggest that the relationship between learning styles, distance education course material and the identification of specific behaviours in the use of CBI material is significant and deserves continued research.

Chapter 10.

Reading Time Behaviour and Preferences for Visual and Verbal Learning Style

Abstract

Data from LearningBooks 09, 12, 13 and 15 in the 2001 study was analysed to look at the proportional amount of time each individual spent reading in comparison with the total time they spent working on a LearningBook. There was a significant negative correlation between the proportional amount of reading time in LearningBooks 12 and 13 ($r_{Pearson} = -0.578$, $p = 0.049$). Students' visual and verbal preferences as measured by an adapted version of Antonietti and Giorgetti's Questionnaire on Visual and Verbal Strategies were also explored. A positive significant correlation was also found between visual preference and the reading time in LearningBook 13 ($r_{spearman} = 0.738$, $p = 0.006$), but not with any other LearningBooks studied. It is hypothesised that both findings might be due to change in LearningBook content. These results and others are discussed.

Introduction

AESOP was designed to be able to record students' activities so that they can be faithfully replayed on a local machine (Chapter 2). One of the activities it records, which has not been studied before, is the different windows being used when an activity takes place within them as a student works their way through a LearningBook (LB). The way in which students use these LB windows can be explored to look for the differences and similarities in behaviour of students' use of online materials and how this behaviour relates to individual characteristics.

The online practical material of the course *M206: An Object Oriented Approach* (*The Open University,* 1998b) is provided as a series of LBs each of which is broken into sessions with a number of practicals in each session. A feature of the practical material is that the practical instructions are presented online, written in HTML, and are not paper based, so students are expected to read them online. Since AESOP records activity taking place within the *Practicals and Notes* pages and activity within the working space, this makes it feasible to differentiate between reading in the *Practicals and Notes* page and performing an activity. In addition, all recorded events are also date and time stamped which allows an estimate of the time students spend in each window to be established. However, students' use of the *Practicals and Notes* pages could be related to individual characteristics of students including reading speed or preference for the visual and verbal learning styles, such that students who have a greater preference for the verbal style may spend more time reading than other students, or may spend less time reading as their preference for the verbal learning style means they are quicker at processing verbal information.

Another consideration when looking at the amount of time students spent reading was that the amount of time students spent using a LB varied greatly (Chapter 3), and consequently the amount of time they spent reading was likely to be a reflection of this. It was therefore necessary to calculate the amount of time spent reading as a proportion of the total time students had spent in the LB. This data was already available in the form of the Total Active Time.

As recordings data, along with data on some individual characteristics for students, including visual and verbal preferences, was available in the 2001 study, it was decided to use this data to explore individual differences in the relative amount of time students spent using the *Practicals and Notes* pages in comparison with the time they spent in the LB and also explore the relationship between this and visual and verbal preferences.

Layout of M206: An object oriented approach

All LBs are divided into two main sections: the *Practicals and Notes* section, containing the instructional text, and the actual *Working Area* where students carry out the practical instructions. Each section is divided into a number of pages. The *Practicals and Notes* section is divided into the Practicals page, a page presenting the HTML files with the instructions for the practicals and subsequent discussions about each activity, and the Notes page, a blank page with various text tools where students can write their own notes. The *Working Area* section is divided into different pages according to the pedagogical content of each LB. In general as the course progresses more pages are added to this section. For instance, in LB09 the working area contains just the *Workspace* (an area for writing and evaluating expressions as well as viewing the message answers and state of an object) and *World* (a graphical representations of the objects and their state), while LB15 contains the *Workspace, World, Class Browser, Precedence* and *Argument* pages. Images of each of these pages are given in Chapter 11, Figures 2a & 2b, and Figures 3a-3e.

When a LB is started the initial window to open is the *Practicals and Notes* section containing the Contents page to all the practical text in the LB (example given in Figure 10.1), with hyperlinks to the Introduction, each Session within the LB, and the individual practicals and their related discussions. Typically a student is expected to navigate to the Introduction from the Contents page and then follow the practicals in the LB in sequence, but it is possible for a student to go directly to any document.

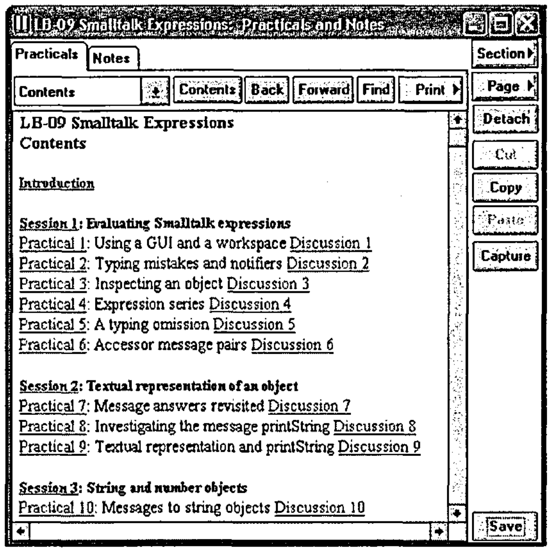


Figure 10.1: Showing the initial page (Contents) that opens on starting a LB and demonstrating the basic layout of a LB window. Text hyperlinked to other pages is underlined.

Reading Time Calculation

An accepted difficulty with AESOP and remote observation is that without direct visual confirmation, or other form of validation, any behaviour associated with a pattern of activity observed in the textual log of the recording is an assumption. This is particularly true of reading, where without the additional evidence of actually seeing where students look, reading can only be assumed from particular patterns of activity that would be consistent with this behaviour, for instance, pauses between scrolling in a window containing text. However, the number and types of events recorded by AESOP provide a level of detail which allows us to examine patterns of activity and build up a story board of a user's activity. When these patterns of behaviour are also analysed with the elapsed time that happens between the events within it, a clearer idea emerges of the behaviour that is taking place. Further support for any associations between a pattern of activity and assumed reading comes from the instructional text visible to users at each point where, if it can be seen that students are carrying out the instructions, this indicates that reading is likely to be taking place.

An example of how reading can be identified from the AESOP recordings is illustrated below in a short comparison between a user's record and the associated story board. Table 10.1, shows a reproduction of the first 25 lines of recording for LB09 (for clarity line numbers have been added and the date stamp has been omitted). The textual content of *Session 1: Evaluating Smalltalk Expressions* which is used in the recording between lines 6 - 20 is presented in Figure 10.2.

In conjunction with Table 10.1, Table 10.2 shows an annotated series of screen shots, reconstructed from the recording and presents the LB09 material as the user would have seen it. From Table 10.1 and Table 10.2 it can be seen that there are sequences of activity which are consistent with a user reading material and these sequences of activity are coded with 'R' in Table 10.1.

Session 1: Evaluating Smalltalk expressions

A workspace is introduced here, and then used in all the practicals in this LearningBook. Your previous knowledge of inspectors is extended, message expressions are revised and expression series developed.

Since typing mistakes are common, the various error reports are displayed as you are asked to make deliberation mistakes. Guidance is given on finding and correcting incorrect typing.

Accessor message pairs are described.

Detach this Practicals page by clicking once on the Detach button.

From the Section menu, select Expressions. The section should open with the World page visible. Place the two pages (World and Practicals) as near to side by side as possible. You will be working on the Workspace page and the World page. If one of these pages is detached, the two pages can be seen at the same time; or you can switch between the two pages with the tabs.

Select a practical from the menu button above or click on a hyperlink below.

Practical 1: Using a GUI and a workspace
Practical 2: Typing mistakes and notifiers
Practical 3: Inspecting an object
Practical 4: Expression series
Practical 5: A typing omission
Practical 6: Accessor message pairs

Figure 10.2: Showing content of Session1 (c09s1.htm) for LB09. The text is as provided to the student.

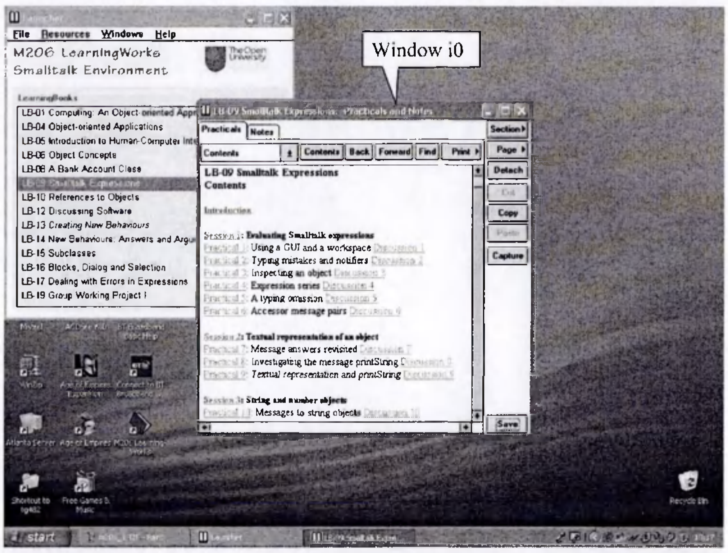
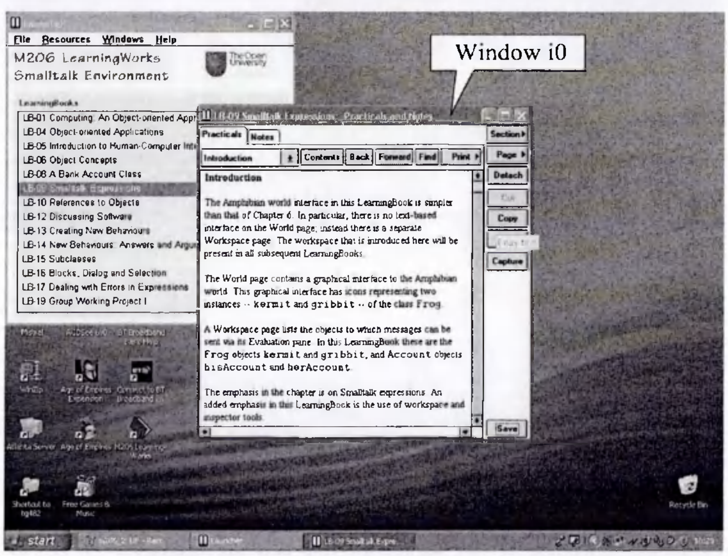
Table 10.1: Showing the annotated first 25 lines of a user's recording in LB09

Line	Text based record of activity	Time stamp	Description of activity	Reading
1	openUserVersion:false	14:03:58	A copy of LB09 is initiated by user.	
2	bounds:rectp276p161p748p607 window:i0/LB-09 Smalltalk Expressions	14:04:00	Initial LB09 window displayed (Window i0) (Figure 10.1)	
3	selectAnchor:c09i.htm	14:04:02	User selects hyperlink to the Introduction page. 43 seconds elapse before the next activity suggesting the user may be reading the material.	R
4	scrollVertically:n162 in:htmlView	14:04:45	User scrolls down page	
5	scrollVertically:p0 in:htmlView	14:04:45	User scrolls down page	
6	selectAnchor:c09s1.htm	14:04:45	**User selects hyperlink to "Session 1: Evaluating Smalltalk expressions."**	
7	detachPage	14:04:49	**User detaches Session 1 page (Window i1) as suggested in text (Figure 10.2).**	
8	bounds:rectp276p175p748p594 window:i1/LB-09 Smalltalk Expressions: Practicals and Notes: Practicals	14:04:50	**New window (Window i1) displayed in front of Window i0 with copy of the text.**	
9	bounds:rectp270p175p742p594 window:i1/LB-09 Smalltalk Expressions: Practicals and Notes: Practicals	14:04:53	**User moves window Window i1.**	
10	bounds:rectp4p27p476p447 window:i1/LB-09 Smalltalk Expressions: Practicals and Notes: Practicals	14:04:57	**User moves window Window i1.**	**R**
11	bounds:rectp4p27p476p735 window:i1/LB-09 Smalltalk Expressions: Practicals and Notes: Practicals	14:05:05	**8 seconds delay before user increases size of Window i1.**	
12	bounds:rectp476p61p948p507 window:i0/LB-09 Smalltalk Expressions	14:05:06	**User moves Window i0.**	
13	bounds:rectp496p45p968p491 window:i0/LB-09 Smalltalk Expressions	14:05:07	**User moves Window i0.**	**R**
14	bounds:rectp529p22p1019p739 window:i0/LB-09 Smalltalk Expressions	14:05:12	**5 seconds delay, then user resizes Window i0, bringing bottom margin close to base of available screen.**	
15	bounds:rectp4p27p489p735 window:i1/LB-09 Smalltalk Expressions: Practicals and Notes: Practicals	14:05:13	**User resizes Window i1.**	**R**
16	bounds:rectp4p27p512p735 window:i1/LB-09 Smalltalk Expressions: Practicals and Notes: Practicals	14:05:24	**11 seconds delay. Then user selects and resizes window Window i1.**	
17	enter:i0/LB-09 Smalltalk Expressions	14:05:24	**User enters window Window i0.**	
18	MENU Label for ''/'Expressions'	14:05:25	**User selects 'Expressions' from the Menu.**	
19	section:Expressions	14:05:25	**'Expressions' Section displayed.**	**R**
20	enter:i1/LB-09 Smalltalk Expressions: Practicals and Notes: Practicals	14:05:32	**7 seconds delay. User enters window Window i1 Session 1**	
21	selectAnchor:c09s1p1.htm	14:05:33	User selects the hyperlink to the first practical "Practical 1: Using a GUI and a workspace."	R

Line	Text based record of activity	Time stamp	Description of activity	Reading
22	`enter:i0/LB-09 Smalltalk Expressions`	`14:07:15`	102 seconds delay. User enters the Expression window.	
23	`tab:i2 'Workspace'`	`14:07:19`	User selects the Workspace tab and makes the workspace visible.	
24	`enter:i1/LB-09 Smalltalk Expressions: Practicals and Notes: Practicals`	`14:07:21`	User selects the Practical 1 page.	R
25	`scrollVertically:n1539 in:htmlView`	`14:10:13`	172 seconds delay. User then scrolls down the Practical page.	

Table 10.1: Annotated reproduction of the first 25 lines of a student's recording while working through LB09.

Table 10.2: Story board of screen shots following a user's progress through LB09 as detailed in Table 10.1.

<table>
<tr><th>Image viewed on screen</th><th>Associated activity in Table 10.1</th></tr>
<tr><td>
</td><td>Line 2: 'Initial LB09 window (Window i0) displayed</td></tr>
<tr><td>
</td><td>Line 3: User selects the Introduction hyperlink (c09i.htm). Contents of this are displayed and there is a pause of 43 seconds before the user scrolls further down the page.</td></tr>
</table>

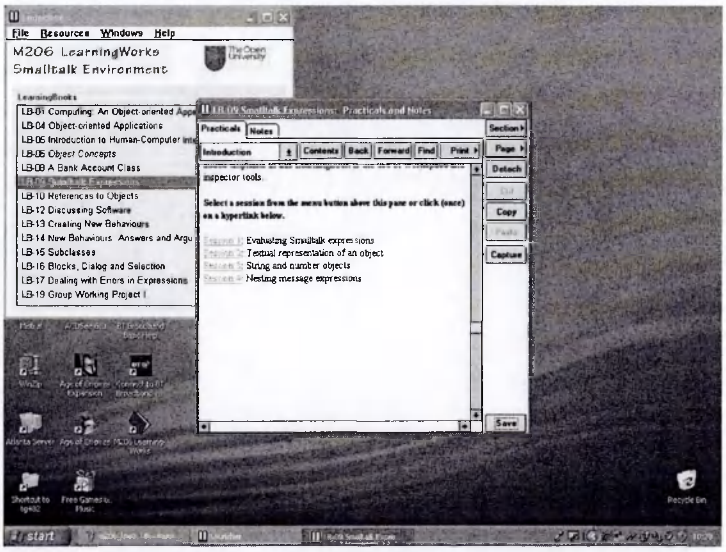
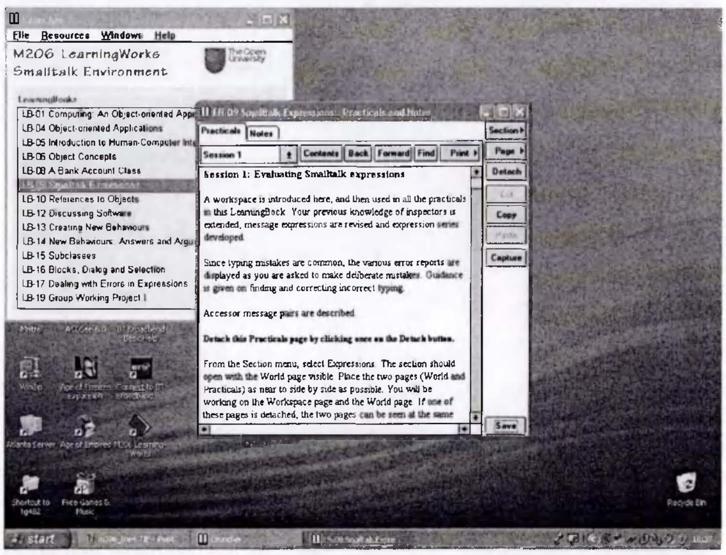
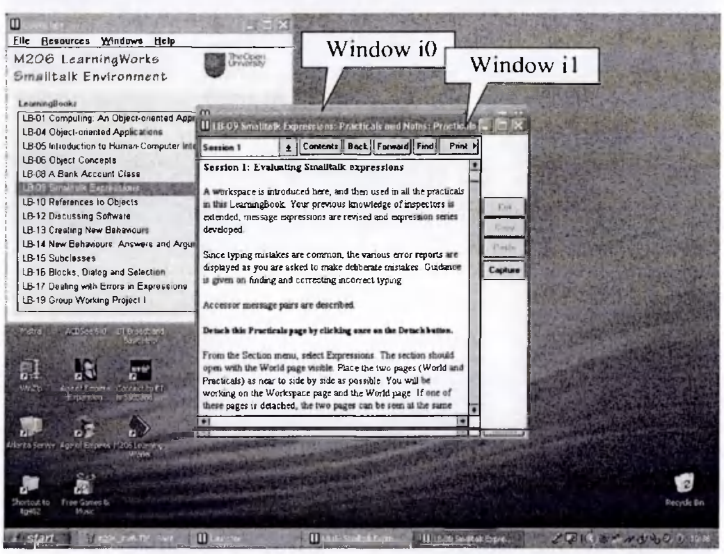
<table>
<tr><th colspan="2">Table 10.2: Story board of screen shots following a user's progress through LB09 as detailed in Table 10.1.</th></tr>
<tr><th>Image viewed on screen</th><th>Associated activity in Table 10.1</th></tr>
<tr><td>
</td><td>Lines 4 and 5: User scrolls further down the Introduction (displayed in Window i0) to the hyperlinks.</td></tr>
<tr><td>
</td><td>Line 6: User selects the hyperlink to Session 1 the contents of which are now displayed in Window i0</td></tr>
<tr><td>
</td><td>Lines 7 and 8: User detaches page, the contents of which are displayed in a satellite Window i1. Window i1 is by default displayed initially in front of Window i0.</td></tr>
</table>

Table 10.2: Story board of screen shots following a user's progress through LB09 as detailed in Table 10.1.

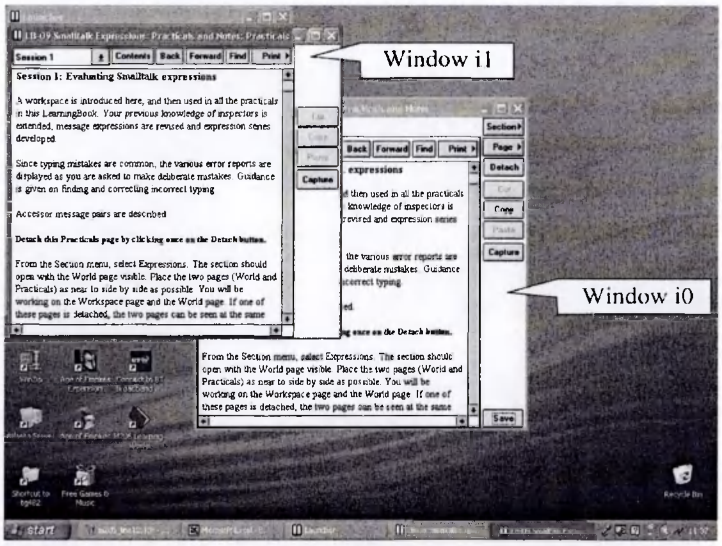
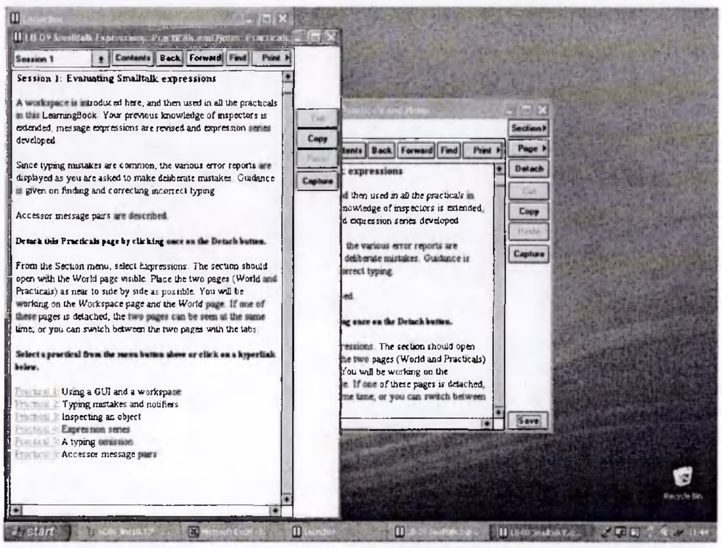
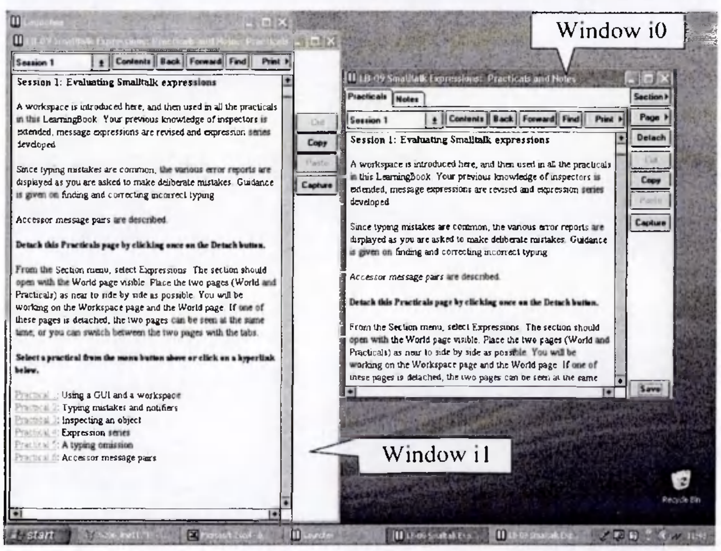
Image viewed on screen	Associated activity in Table 10.1
	Lines 9 and 10: User moves Window i1 to the upper left hand corner of the screen. There is a short pause of 8 seconds before the next action.
	Line 11: User increases the size of Window i1.
	Line 12: User moves Window i0 so it is side-by-side with Window i1 as suggested in the text.

Table 10.2: Story board of screen shots following a user's progress through LB09 as detailed in Table 10.1.

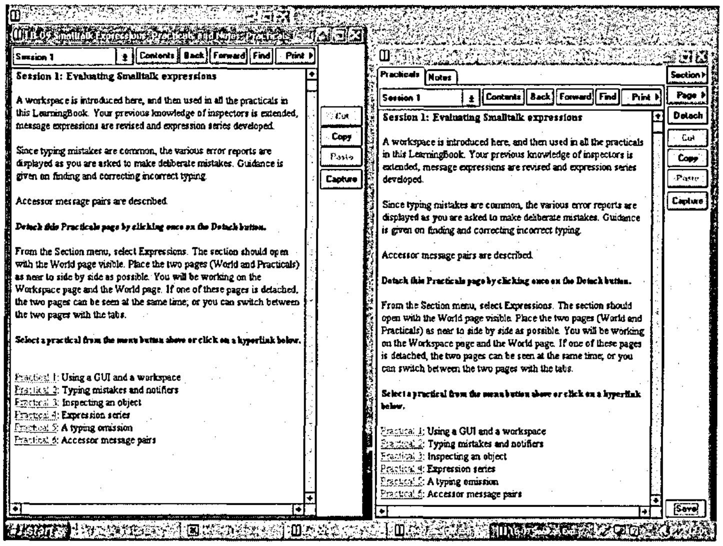
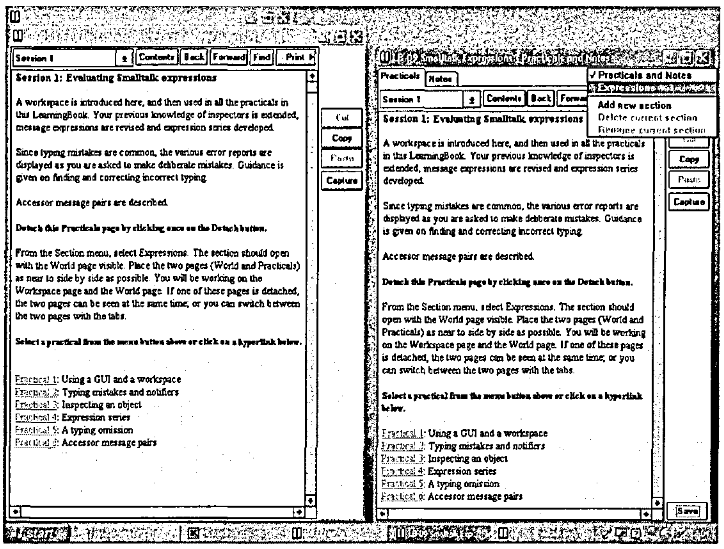
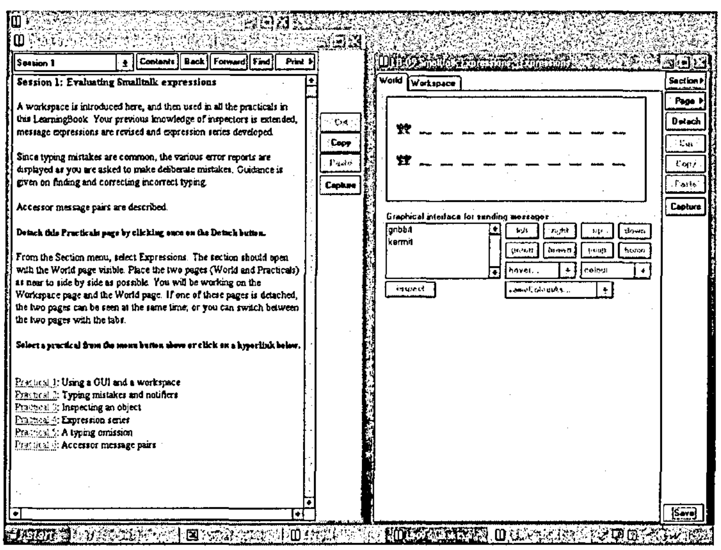
Image viewed on screen	Associated activity in Table 10.1
	Lines 13 - 16: Positions of widows after user has resized and adjusted the placements of Windows i0 and i1.
	Line 18: User following instructions from the text selects Expressions (Working Area section) from the Section button (visible in top right of window in previous view) and subsequently displayed menu. This follows instructions in the text.
	Line 19: Expressions section showing the World page and Workspace page (accessible via the tab) now displayed in Window i0.

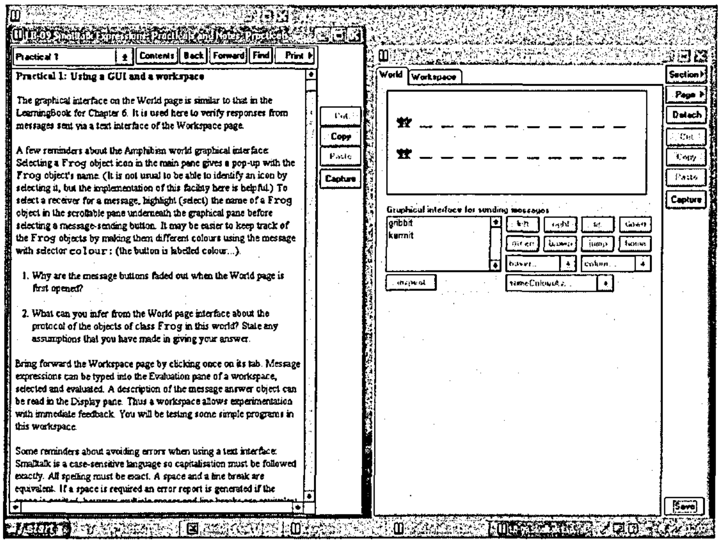
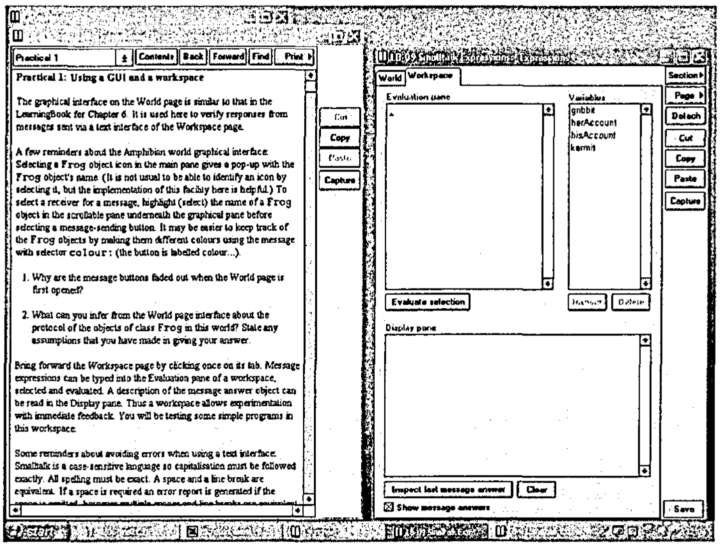
Table 10.2: Story board of screen shots following a user's progress through LB09 as detailed in Table 10.1.	
Image viewed on screen	Associated activity in Table 10.1
	Lines 20 and 21, User returns to window i1 selects hyperlink in this window to "Practical 1: Using a GUI and a workspace." which is now displayed.
	Lines 22 and 23: user returns to Window i0 and selects the Workspace tab. The instruction to do this can be seen two thirds of the way down the page.

Table 10.2: Story board of screen shots highlighting a user's progress through LB09 as detailed in Table 10.1. Windows with their nomenclature are labelled at points for clarity.

In this study recordings were analysed by hand using Microsoft Excel© to import the text based recordings and then identify and mark those patterns of activity that were consistent with reading. Generally reading time was assumed to be happening at those times when a student was noted to have entered the *Practical* page for a duration of time before returning to the workspace and carrying out practical tasks. It was presumed that the majority of time spent in this window was reading because other activities, such as scrolling and selecting hyperlinks within the *Practical* page, indicate that the student's attention was within the Practical page window.

The amount of time that a user had spent reading (using the above definition) was then calculated. However, because time has to be allowed for activities such as moving and resizing windows to be completed within the *Practical* page, events taking 4 seconds or less of elapsed time between them were excluded from the analysis as analysis of the records showed that 4 seconds was the general maximum amount of elapsed time between events such as scrolling down page, before longer periods where reading was clearly taking place. In addition to this, individual periods of inactivity that exceeded 300 seconds (5 minutes) were also excluded from analysis. These were excluded to allow the ratio to be calculated between the amount of time spent reading and the amount of time a user spent actively working in a LB, the TAT, as the time a user spent reading is a sub-set of the activities calculated within the TAT. Calculation of the TAT and the selection of 300 seconds as the cut-off point are described in more detail in Chapter 3.

The calculated TAT for a LB is a measure of the total time students spent within it, including all occasions when they have opened the LB on different days and times. To allow for the calculated reading time to be comparative, all occasions when a student had been noted to have spent time reading through the whole recording were noted and the sum of those times calculated. This was regarded as the Total Reading Time (TRT).

Selection of LBs

Several LBs were examined to gain a better picture of any general behavioural trends that students may exhibit either individually or in a group. LB09, LB12 and LB13 were selected for analysis as they were beyond the introductory stages of the course, but required set responses, that is students were told the programming code to type. To see if the type of task influenced the time students took in reading, LB15 was also selected as a comparison as students are asked to develop their own code as opposed to trying a set response.

Results

The number of recordings that could be analysed against visual and verbal preferences varied between 11 for LB 09 and 15 for LB 15 (Table 10.3).

	Male	Female	Total
LB 09	8	3	11
LB 12	9	5	14
LB 13	9	5	14
LB 15	10	5	15

Table 10.3: Number of recordings available for analysis for each LearningBook by gender

Although the number or recordings available for analysis varied between LBs, the recordings were from the same small set of students each time allowing the analysis between LBs to be comparable.

Students' Visual Display Unit Resolution

One finding in Chapter 3 has been that students using a screen resolution of 640 x 480 pixels took significantly longer than those using a higher resolution setting. Because of this, and the fact students used their own machines to study, there was a possibility of observing different behaviours depending on the VDU resolutions used. Data from the CGDQ however, indicated that all subjects in the analysis used visual display units at 800 x 600 pixels resolution and therefore VDU resolution was not felt a significant factor to be considered in the present analysis.

Total Reading Time

In two cases in LB09, recordings were excluded from analysis as students had short incomplete recordings where there was no usage of the *Practicals and Notes* window. Because of their incompleteness these cases were therefore not felt to be an accurate representation of students' activity within the LB and so were not used. Four additional records were also filtered and excluded from analysis, one record from each of LB 09 and 12, and two from LB 13, as each involved no more than 5 minutes of total activity (TAT) during which no practical activity was attempted and only a very short period of initial reading (e.g. 4 seconds). These cases where students had briefly looked at the LB but had not carried out any activities were noted to be different students in each LB.

The range of TRTs found over the 4 LBs is given Table 10.4. There was considerable variation in the range of TRTs found, ranging from 216 seconds to 14656 seconds.

TRT	**N**	**Min (s)**	**Max (s)**	**Mean (s)**	**Std. Dev**
LB09	8	1042	14656	4590.25	4445.939
LB12	13	216	3812	1793.08	1289.224
LB13	12	449	3183	1436.83	848.810
LB15	15	588	4074	1883.93	993.057

Table 10.4: Descriptive statistics of the Total Reading Times (TRT) in the subset of records used for analysis.

As already discussed, the TRT by itself is not informative as it needs to be considered in relation to the TAT spent by each student in a LB. To enable this comparison, a variable called the *Reading Time Ratio* (RTR) was calculated from these two results:

$$RTR = \frac{TRT}{TAT}$$

A summary of the RTRs calculated for each LB are given in Table 10.5.

RTR	N	Min (s)	Max (s)	Mean (s)	Std. Dev
LB09	8	0.324	0.639	0.478	0.108
LB12	13	0.058	0.671	0.403	0.178
LB13	12	0.142	0.508	0.309	0.116
LB15	15	0.036	0.454	0.215	0.132

Table 10.5: Descriptive statistics of the derived Reading Time Ratio (RTR) for each LearningBook (LB).

A more detailed examination of the data is shown in Figure 10.3, which plots students individual RTRs for each LB and the correlations between the LBs given in Table 10.6.

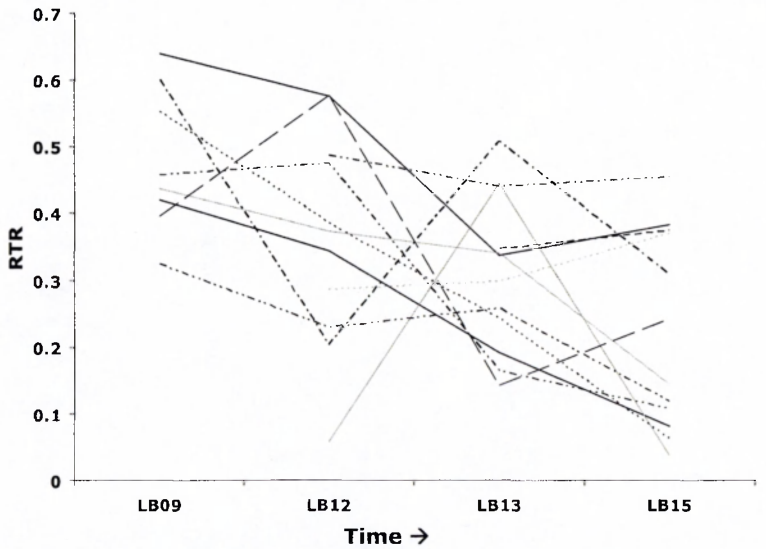


Figure 10.3: Detailing individual students' Reading Time Ratios (RTR) for various LearningBooks in temporal sequence. Each line represents the change in RTR from LearningBook to LearningBook of an individual.

Figure 10.3. shows the variability between LBs for individuals and the apparent consistent drop in the mean proportional amount of time students spent reading. Table 10.6 shows a significant correlation between LBs 12 and 13 ($r_{Pearson}$ = -0.578, p = 0.049), the other correlations are not significant.

This indicates that students who spent a short time to reading in comparison to time spend working in LB12 took a longer time reading in LB13 and vice versa. In LB13 students are introduced to the *Class Browser* and also asked to create two new methods although students are given a template for the methods from which to work from. It is possible that this negative correlation reflects a change in task from the prescriptive activities in LB12. An overview of these LBs content is given in Chapter 2.

		RTR LBL09	RTR LBL12	RTR LBL13	RTR LBL15
RTR LBL09	$r_{Pearson}$		0.166	0.591	0.593
	Sig. (2-tailed)		0.694	0.123	0.122
	N		8	8	8
RTR LBL12	$r_{Pearson}$	0.166		**-0.578**	0.226
	Sig. (2-tailed)	0.694		0.049	0.458
	N	8		12	13
RTR LBL13	$r_{Pearson}$	0.591	**-0.578**		0.121
	Sig. (2-tailed)	0.123	0.049		0.681
	N	8	12		12

Table 10.6: Pearson correlations between the Reading Time Ratios for LB 09, 12, 13 and 15.

Reading Time Ratio and Visual Verbal Preferences

In addition to exploring individual differences in the amount of time that students spent reading in the *Practicals and Notes* pages, we also wanted to explore what relationships, if any, exist between this and the individual characteristics of visual and verbal learning style preferences. To assess this, individuals' visual and verbal preferences were obtained from their responses to an English adaptation of Antonietti and Giorgetti's questionnaire on Visual and Verbal Strategies ($QVVS_{Eng}$), as compared to the normative data of other distance education students (Chapter 8). The results of this given in Figure 10.4 to Figure 10.7 which show the relationships found between individual student's RTRs for each LB against their preference for visual or verbal strategies. The Spearman correlations between students visual and verbal preferences and RTR are given in Table 10.7.

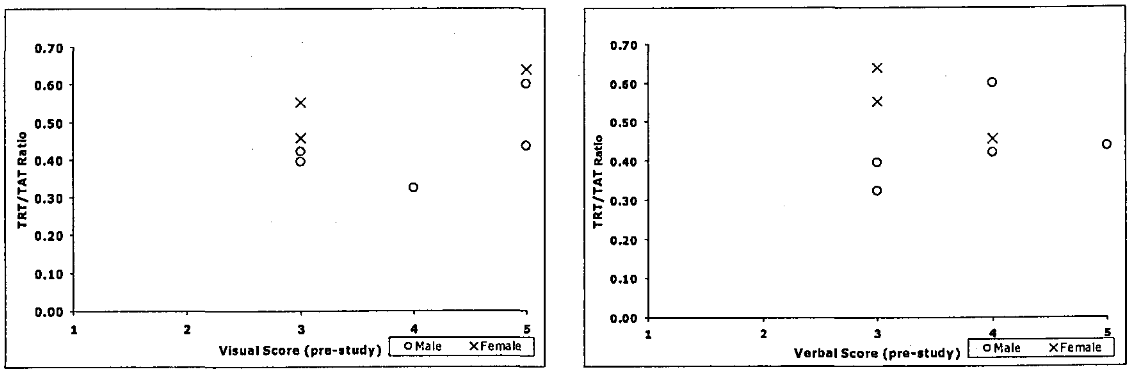


Figure 10.4: Comparison of individual's visual or verbal preferences with their Reading Time Ratios (TRT/TAT) in LB 09.

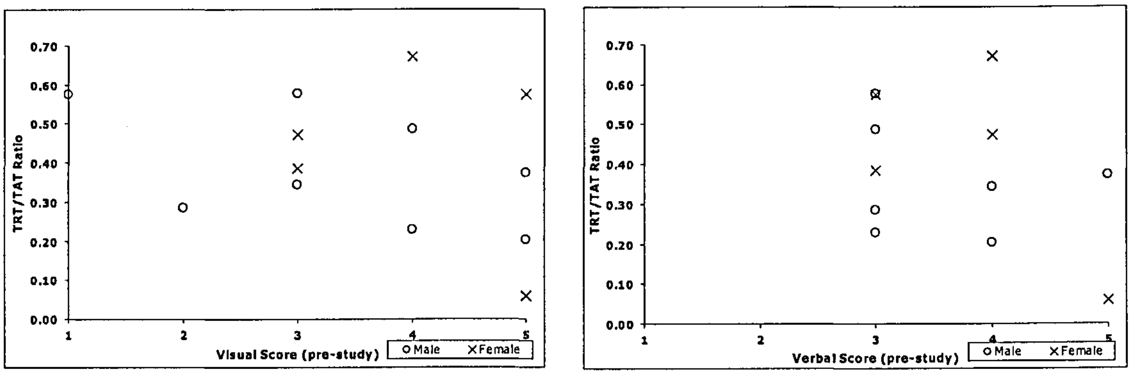


Figure 10.5: Comparison of individual's visual or verbal preferences with their Reading Time Ratios (TRT/TAT) in LB 12.

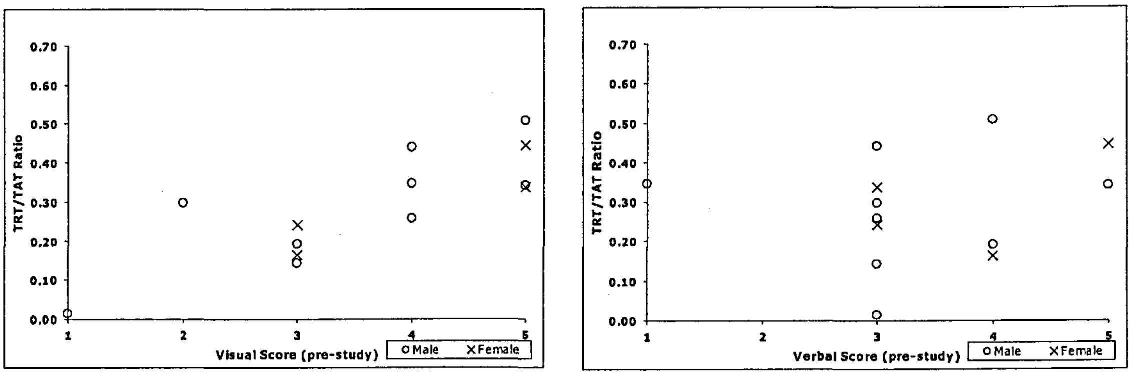


Figure 10.6: Comparison of individual's visual or verbal preferences with their Reading Time Ratios (TRT/TAT) in LB 13.

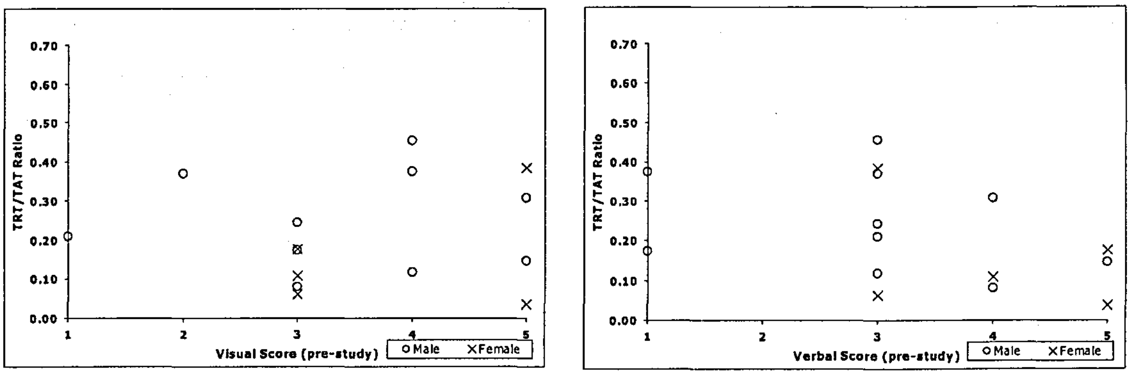


Figure 10.7: Comparison of individual's visual or verbal preferences with their Reading Time Ratios (TRT/TAT) in LB 15.

With the exception of LB 13, there were no significant relationships found between the proportional amount of time individuals spent reading and their visual or verbal preferences. In LB 13 (Figure 10.6) there was a highly significant positive correlation between individuals' visual preference and amount of time they spent reading ($r_{spearman}$ = 0.738, p = 0.006).

		RTR LBL09	RTR LBL12	RTR LBL13	RTR LBL15
Visual	$r_{speasrman}$	0.149	-0.347	0.738	0.082
	Sig. (2-tailed)	0.702	0.224	0.006	0.771
	N	8	13	12	15
Verbal	$r_{spearman}$	-0.275	-0.500	0.367	-0.456
	Sig. (2-tailed)	0.474	0.069	0.196	0.088
	N	8	13	12	15

Table 10.7: Spearman correlations between Students Visual and Verbal preferences and their Reading Time Ratios for LB 09, 12, 13 and 15.

Discussion

It was noted that the mean RTR spent in each LB generally decreased as the course progressed. That is, proportionally less time is spent reading in later LBs than in earlier ones. However, this was a general trend not reflected in the pattern between LBs by individuals. This is supported by the lack of significant correlations indicating a lack of relationship between the RTRs for each LB except between LBs 12 and 13 (Table 10.6).

Investigation into the reason for the general decline in RTRs found that as the course progressed the mean TAT spent by students on each LB increased (Table 10.8), and that the more time a student spent actively working with the materials, proportionally less time was spent reading.

One possibility for students spending more time being active is that they are becoming more engaged with the materials and spending more time exploring as the materials become more complex. For instance in LB09 students are only offered the *World* and *Workspace*, in the working area but in LB15 they are offered in addition to these the *Class Browser*, *Precedence* and *Argument*. In addition, in LB15 the nature of the task also changes from being passive and evaluating code they have been given to creating their own code to create the behaviours requested.

	N	Min (s)	Max (s)	Mean (s)	Std. Dev.
TAT LB09	8	1050	24442	7412.40	7077.225
TAT LB12	13	859	10563	4935.15	3384.247
TAT LB13	12	1292	11034	5064.00	3157.633
TAT LB15	15	2910	41554	12227.93	9728.365

Table 10.8: Showing the change in Total Active Time (TAT) taken to complete LearningBooks (LB) as the course progresses.

A finding of interest was the presence of a significant negative correlation between the RTR in LB12 and the RTR in LB13 ($r_{Pearson} = -0.578$, $p = 0.049$). That is, those students who spent less time reading in LB12 were noted to take more time reading in LB13 and vice versa. The content of LB13 is different to LB12 by introducing the *Class Browser* as well as asking students to create methods following a template, while LB12 is more prescriptive. One conjecture is that this change in students' behaviour is related to the change of content.

In LB13 there was also a significant positive correlation of 0.738 between students' visual preference and the RTR ($r_{spearman} = 0.738$, $p = 0.006$), such that those who expressed a greater visual preference spent more time reading in LB13 than those who had a lower visual preference. It is possible that the same reason for the negative correlation between the RTR and in LB12 and 13 is the same for the correlation found between visual preference and LB13. LB13 is the first time students have been presented with the *Class Browser* and asked to write two methods from a template (similar methods for a different instance are given). The *Class Browser* (Figure 10.8), is a resource that requires more verbal processing than visual, and a conjecture is that those students with stronger visual preferences were not able to rely on their visual skills to help understand the browser and consequently spent a longer time reading. Further study is needed to confirm whether students who are more visual take longer to process information from the *Class Browser*, and it may be that students would benefit from having the information presented in different ways, such as mind-maps (Buzan, 2004) as used in Visual Mind™ (*Mind Technologies AS,* 2005)

There are however some considerations of these results, the first is the number of students recordings available for analyses ($N_{max} = 15$). Another major consideration of these results is that they are based on what has been determined in this study as *reading behaviour* and only within the *Practicals and Notes* pages of each LB. Without direct observation of students, which was impossible in this study, it is not possible to determine exactly what constituted actual reading behaviour and what did not. *Reading behaviour* therefore within this study was constrained to those sequences of activity in recordings which were consistent with reading taking place and was an estimated value. A more accurate construct of what sequences of activity constitute reading could be gained through the use of eye-tracking (Vertegaal, 1999; Vertegaal and Ding, 2002; Tzanidou, 2003; Vertegaal, 2003) where the location and duration of students' gaze can be monitored and would also provided information on how accurate the manual selection of activities judged to be reading are. However, eye tracking is reliant on specialist hardware for tracking individuals' gaze making it impractical to monitor every student, but it could be used in a series of small studies that for future reference would provide a more accurate construct of what events and sequences of activities constitute reading.

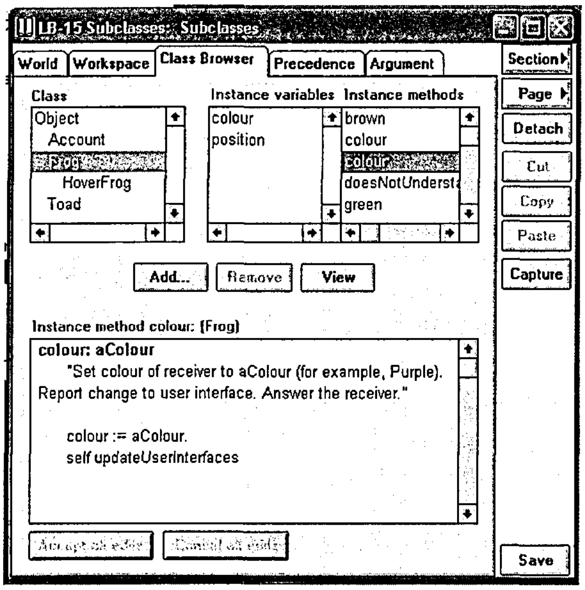


Figure 10.8: Image of the Class Browser page as would be seen by a student viewing the method: colour for Class: Frog. Selecting a Class causes the related Instance variables and Instance methods for that class to be displayed. Selecting a variable or method brings up its details in the lower pane as demonstrated.

The content of the practical text has some relevance to the amount of time individuals spent reading it. In this study content was not taken into account except for the type of task. However, the practical instructions in addition to the textual descriptions also included the occasional diagram. These diagrams are reproductions of the LearningWorks interface that students are expected to see and are placed there to illustrate the task students are expected to carry out. Because of their nature as illustrative diagrams rather than diagrams that needed a level of comprehension, such as graphs, it was felt that their presence in some practical sessions would not unduly affect whether reading speed would be affected by individual characteristics such as visual and verbal preferences. However, this may be an inaccurate assumption and one that needs testing out.

In LB13 the introduction of the *Class Browser* occurs earlier in the LB than the creation of the two methods. In this work looking at the whole LB it is impossible to distinguish which of these factors, if any, are responsible for the significant relationships found. The approach taken did not take into account individual variations within practicals; variations that may have better relationships to individual characteristics than the overall content of the LB, such as looking at the introduction of the Class Browser separately from the writing of methods. It will therefore be more useful in future studies to narrow the focus on individual practicals rather than whole LBs.

The practical and relevant discussion texts are separate from each other. AESOP does record which one is being used, so another area for future study that would be of interest is to look at the differing amounts of time students spend reading in each of these activities in addition to looking at smaller, more focussed, sections of the LB.

Also for future study is the GUI, the *World*, a page within the working area of the LB that allows students to see a graphical representation of the actions their instructions (code that has been evaluated) has had on an object. It is possible that students who are more visual will use this interface to a greater extent to confirm the actions they undertaken. However, it is also quite feasible that visualisers will use the GUI less as according to the visual construct as measured by the $QVVS_{Eng}$ they have better visual recall and ability to create images and therefore would not need visual confirmation of what they had done. Whether or not a difference was found either way, it would help in the design of the types of interfaces required to meet individualised needs.

Finally, it should be noted that neither total active time nor total reading time are accurate measures: it is difficult to ascertain exactly when reading is taking place, as discussed above, and both measures include periods of inactivity not exceeding five minutes.

Conclusion

This chapter has looked at how much time students spent reading as a proportion of the total amount of time they spent working with online practical material and at the potential relationships between the amount of time students spent reading while using the online practical material and their visual or verbal preferences.

Two findings of interest was the presence of a significant negative correlation between the RTR in LB12 and the RTR in LB13 ($r_{Pearson} = -0.578$, $p = 0.049$) and a significant positive correlation between students' visual preference and the RTR in LB13 ($r_{spearman} = 0.738$, $p = 0.006$). It is conjectured that both findings may be related and due to a change in the content of LB13 from LB12. This requires further work, but two possible reasons are conjectured that suggest ways forward to investigate how the content of CBI could influence students' behaviour in relation to their individual characteristics.

The mean Reading Time Ratio for all students dropped as they progressed through to later LBs and this was found to be related to an increase in the amount of time students spent actively working with the materials, suggesting that as the course progressed students became more actively engaged with the materials and working with them.

It is possible that analysis looking at whole LBs is too general and that using the RTR to look at more discrete sections of a LB or more specific activities would be of greater value in determining any relationships between RTR behaviour and individual characteristics.

Chapter 11.

Small Scale Behavioural Studies

Abstract

In the previous chapters, individual differences in behaviour were studied looking at the data that could be obtained from the date and time stamps for each recorded event. In this chapter a series of small, fine grained analyses of students' recordings from the 2001 study are described looking at three behaviours logged by the AESOP Recorder and exploring their relationships with characteristics of individuals. The behaviours looked at were individuals' arrangements of their online workspace, the sequential use of the practical text and students' use of an additional resource, the *Notes* page.

All 15 records in LB15 were analysed. Students were found to use stacking, tiling, smart tiling or a mix of these to arrange their workspace, but these arrangements did not appear to be related to any individual preferences for visual or verbal learning styles or to screen resolution. There was no consistent use of the notes page by students when compared against other LBs. All students were found to follow the practicals in the sequence delivered by the *M206 Computing: An Object Oriented Approach* course. Several possible explanations for this are discussed including the possibility of students being active learners rather than passive. These findings are discussed in more detail and a number of recommendations for further study are made.

Introduction

The objectives of this thesis have been to investigate the relationships between the factors of time, comfort with computing tasks, selected learning styles and the behaviour of distance education students in the use of CBI material. That is the interaction between these factors and students' behaviours when they study. Although it is not possible to directly record individuals' thought processes, the way students behave as they learn can give us useful information about the way they are thinking and learning. In this thesis the behaviours related to learning being explored are the ways students use the CBI materials for the course *M206 Computing: An Object Oriented Approach.*

The previous chapters of this thesis looked at data that could be taken from the date and time stamp recorded with each event by the AESOP Recorder. However, AESOP was originally developed as a tool to look at how students learn (Thomas et al., 1998a; 1998b; MacGregor et al., 1999; MacGregor, 1999) and designed to record virtually all events that take place within a students' use of a LearningBook (LB). This level of detail within a recording allows us to explore, identify and analyse specific patterns of activity that are of interest and to investigate questions relating to these patterns of activity.

This chapter details the exploration of three areas of activity have been identified as of interest and raise a number of questions, questions that AESOP could be used to answer in future research.

Behaviours recorded by AESOP

Three areas of activity that have been identified within AESOP that are of interest are 1) information on window usage and placement, 2) information from the hyperlinks showing which page of the practical text had been selected and 3) students use of the *Notes* page.

1) Window placement and usage.

One aspect that AESOP records are those events relating to when windows in the LearningWorks environment are created, moved or resized. The method of ascertaining window size and location is given in more detail later in this chapter, but by plotting the location of the windows as they are created, moved or resized it is possible to observe how and in what sequence students arrange the LB windows as they work their way through the online practicals. These observations include information on whether they place windows as tiles, stacked or in a different arrangement and allows us to ask such questions as "How do students arrange their workspace?", "Do students change this arrangement during a practical?".

The relevance of this is that when working with online materials, students are restricted by the space available to them on their monitors. An aspect of this is the increased demands placed on working memory (Baddeley, 1987; 1990; 1992) when users stack windows (where the content of any windows underneath the one on top are not visible), as these users will need to hold information about the content of those windows that are no longer visible, whereas those who tile windows (place them side by side) are not reliant on working memory to hold this information. Because of the implications for performance depending on working memory capacity and whether stacking or tiling was used, recordings were examined to identify the initial window placement and the how users organised their workspace.

2) Use of additional resources

As well as window placement and size, AESOP records the identity of the LB page being accessed. An observation made during preliminary work into the first study on window placement identified that some students accessed the *Notes page* (part of the *Practicals and Notes* section) while others did not. This finding prompted further exploratory work into the questions of which students take their own notes and the type of notes that they take.

3) Students usage of the practical text

Another aspect recorded by AESOP is the HTML practical pages that students access. As discussed in Chapter 10, the practical text is presented within a page which students are expected to detach as a separate window and use alongside the main window displaying the working area. Each practical is divided into a set of activities and a hyperlink to a discussion with the expected answer. The related discussions are presented as a separate HTML file to each practical. Although students are expected to follow the sequence of practical first, discussion second, it is possible to look at practicals and their discussion in any sequence, so if a student chose to they could look at the discussions before carrying out the practical or look at just the discussions or just the practicals.

AESOP's ability to record which HTML files are being accessed allows us to explore such questions as "In what order do students perform course related activities?", "Do students follow the course sequence as it was designed?" and "If students don't follow the course-sequence does this have any implications?" If most or no students follow the course-sequence this would suggest they prefer a different approach which the course is not addressing.

Since the discussion contains the expected answers, another question is the extent to which students access the discussion before the practical or the discussions alone. A conjecture made here is that students who are passive learners will look at the discussion first to seek out the answers while students who are active will carry out the practicals first.

As AESOP provides information on which HTML file is being accessed and in which sequence; and there may be a number of implications behind how students approached the sequence of practicals. This was another aspect felt worthwhile to explore.

Consistency in the tasks

M206 is a distance education course with students studying the material in their own time and in different environments. It is not possible to control the environment external to the machine that students are using to study the course materials. However, students are all studying the same course, being set the same tasks and having this presented to them initially in an identical way when they are being recorded. This means that any observed differences or commonalities in patterns of activity between students are likely to be due to individuals' preferences and not a reflection of any differences in the availability of materials or the task that was set. Therefore, the recordings could be searched for evidence of such differences and commonalities.

Data

Students' preferences for active and passive learning are not directly measured by any of the learning styles that were used to survey the distance education students. However, two of the styles used have characteristics that are similar to a preference for active learning. These are the *Activist* learning style on Honey and Mumford's Learning Styles Questionnaire (Honey and Mumford, 1986; Mumford, 1991; Honey and Mumford, 1995) and the *Participant* learning style on Grasha and Riechmann's Student Learning Styles Scales (Riechmann and Grasha, 1974; Grasha, 1996b). Both of were selected as data was available on these styles.

Data from the 2001 study was selected as this had recordings from students and background information on students including individual preferences for learning styles that may be related to any observed behaviours.

LB15 was selected for examination as this had the greatest number of complete recordings and in addition required students to carry out exploratory tasks and create their own solutions to set problems rather than carry out prescribed tasks. This data was chosen because it was felt that by looking at tasks in which students had to create their own solutions, it would offer the best chance of seeing individual characteristics in the behaviours being explored.

Characterisation of Sample

LB15

"LB-15: Subclasses" discusses how to create new classes, how classes inherit behaviour from their superclass and how a class can be modified. The practical is designed to give students experience of initialisation and of creating and modifying classes. As such it is also one of the first chapters that requires students to create their own solutions rather than presenting a solution to students and asking them to observe its effect. Figure 11.1 shows the table of contents for LB15 as would be presented to students in the opening screen.

LB15 is organised into two main sections: (1) *Practicals and Notes* containing the *Practicals* page (Figure 11.2a) and the *Notes page* (Figure 11.2b), and (2) the section with the working area organised into 5 pages with *World* (Figure 11.3a), *Workspace* (Figure 11.3b), *Class Browser* (Figure 11.3c), *Precedence* (Figure 11.3d) and *Argument* (Figure 11.3e) tools. These pages are accessed via tabs within the working area, but can be detached as separate windows.

LB-15 Subclasses
Contents

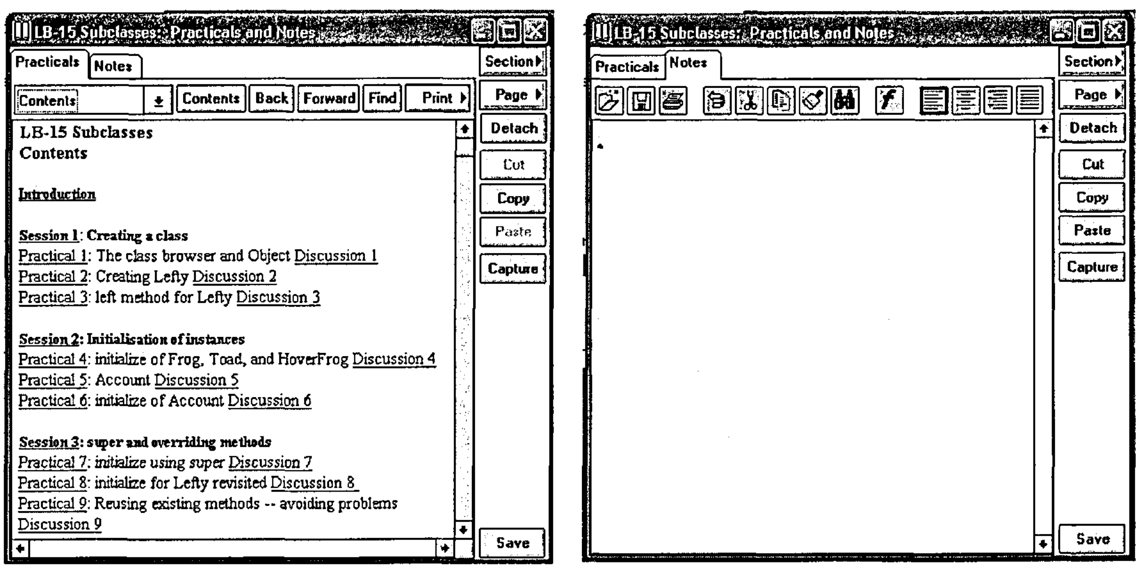
Introduction

Session 1: **Creating a class**
Practical 1: The class browser and Object Discussion 1
Practical 2: Creating Lefty Discussion 2
Practical 3: left method for Lefty Discussion 3

Session 2: **Initialisation of instances**
Practical 4: initialize of Frog, Toad, and HoverFrog Discussion 4
Practical 5: Account Discussion 5
Practical 6: initialize of Account Discussion 6

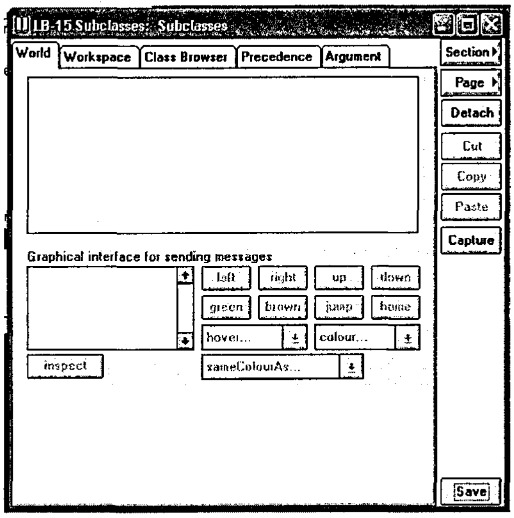
Session 3: **super and overriding methods**
Practical 7: initialize using super Discussion 7
Practical 8: initialize for Lefty revisited Discussion 8
Practical 9: Reusing existing methods -- avoiding problems Discussion 9
Practical 10: swerve -- an additional method without overriding Discussion 10
Practical 11: dodge and super Discussion 11
Practical 12: Deleting initialize for Lefty Discussion 12
Practical 13: super, message precedence and cascading Discussion 13
Practical 14: super -- the search for the correct method Discussion 14

Figure 11.1: Table of Contents for LB15 showing the organisation of the LB into Sessions and the separate practicals.

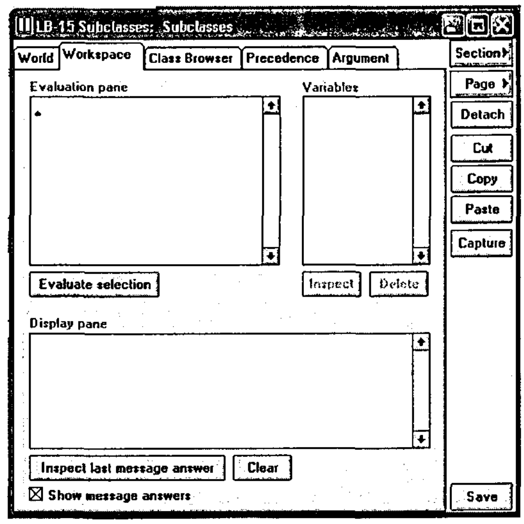


a) Practicals page with Table of Contents *b) Notes page*

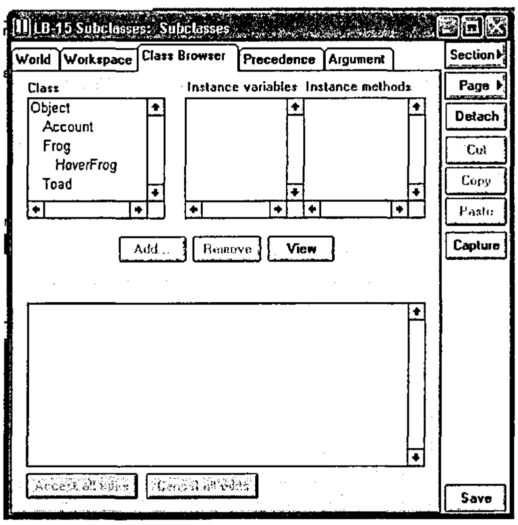
Figure 11.2: showing the 2 pages in the Practicals and Notes section in their initial state as seen by a student.



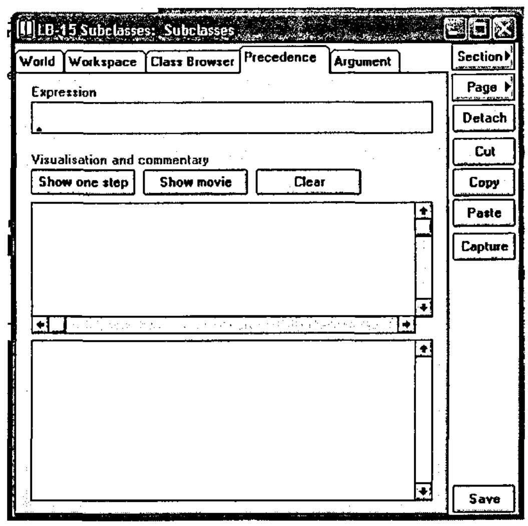
a) World page



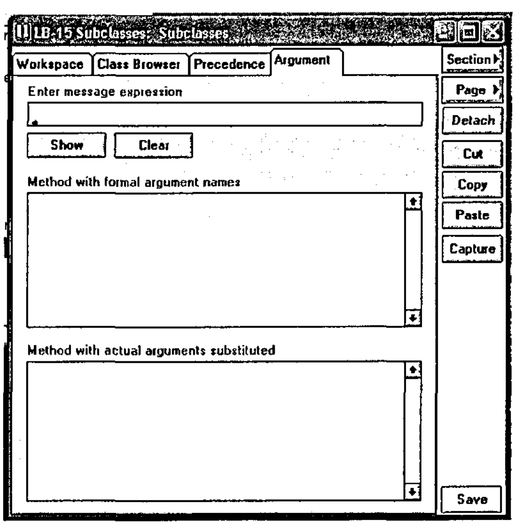
b) Workspace



c) Class Browser



d) Precedence tool



e) Argument tool

Figure 11.3: Showing the 5 pages available in the working area of LB15 in their initial state as seen by a student. (NB. The tab for the World page disappears when the Argument tool is selected, but can be recalled from the Page tool menu button on the right hand side)

Subjects

The number of available recordings for each LB varied. For LB15, 15 students had returned recordings (6 Female, 9 Male). Demographic data on the students was obtained from the Computing General Demographic Questionnaire. All 15 students had prior experience of Open University courses, implying that they were familiar with the academic year and presentation pattern. All students passed the course and were academically similar. 4 students had no previous programming experience. Of these 4, 3 (ID5, ID8 and ID12) had a final Overall Exam Scores (OES) lower than 70 and also had the lowest Overall Continuous Assessment Scores (OCAS), however ID5 who had previous programming experience also had an OES less than 70 (Table 11.1).

Student ID	Gender	Prior Programming Experience	Prior OU Experience	Overall Exam Score	Overall Continuous Assessment Score
ID1	F	Yes	Yes	79	92.3
ID2	M	Yes	Yes	91	91.1
ID3	F	Yes	Yes	81	90.3
ID4	M	Yes	Yes	85	86.9
ID5	M	Yes	Yes	66	68.9
ID6	F	No	Yes	95	96.6
ID7	M	No	Yes	76	89.4
ID8	F	No	Yes	52	78.3
ID9	F	Yes	Yes	76	86.3
ID10	M	Yes	Yes	71	85.6
ID11	F	Yes	Yes	72	83.3
ID12	M	No	Yes	63	72.9
ID13	M	Yes	Yes	83	90.3
ID14	M	Yes	Yes	89	87.0
ID15	M	Yes	Yes	82	90.7

Table 11.1: Showing demographic and background data for students examined in LB15

Analysis of LB recordings

Only one LB can be opened at a time. The relevance of this is that, although other windows applications could be active (but cannot be logged by the Recorder), students will only be studying one LB at a time. In addition, all LBs open the same way independent of the configuration of the machine they are being used on.

Recordings were analysed by hand, using Microsoft Excel© to import and organise the original text file recordings. To help identify events or sequences of events that were of interest, formulae using text functions in Microsoft Excel© were developed to help highlight and isolate the desired details from the text of each event. Detailed examples are given for each study.

Study 1 - Students' arrangement of workspace environment.

How do students organise their online workspace while studying M206? This analysis addresses this question by examining window placement in LB15.

Initial window placement

When LB15 is initiated from the LearningWorks Launcher, the initial window that opens shows the *Practicals* page of the *Practicals and Notes* section with the *Contents* page shown as seen in Figure 11.4 and detailed earlier in Figure 11.1. In addition, a design feature of all LBs is that the initial window opens at a preset dimension of width and height and also a preset location which is irrespective of the user's screen resolution. The initial dimensions are the minimum dimensions this window can be sized to.

The *Contents* page provides hyperlinks to the introduction, each section and the various practicals and subsequent discussions within each section. From the *Contents* page, students are expected to navigate to the Introduction and then to a Session listed within the Introduction. At the start of each Session, students are instructed, as seen in Figure 11.5, to detach the currently displayed page so that they can read the *Practicals* page in a window separate to the one where they carry out the activities in the *Workspace*.

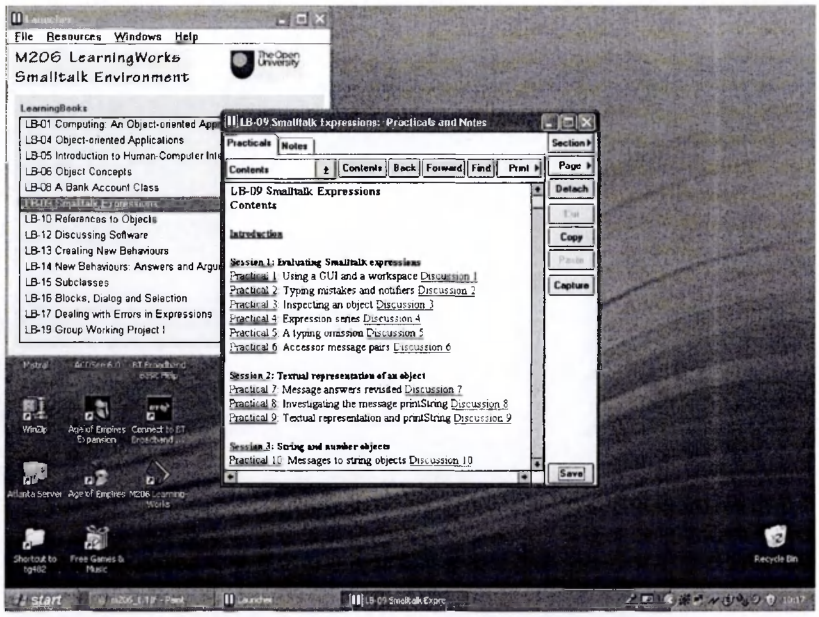


Figure 11.4: Example of the size and position of the initial opening screen for LB15, as seen in a 1024 x 768 pixel resolution display.

Session 1: Creating a class

Session 1 allows you to explore the new class browser which contains an additional class: `Object`. You will also create a new class called `Lefty` (a subclass of `Frog`) and modify its behaviour.

Detach this Practicals page by clicking once on the Detach button.

Select a practical from the menu button above or click on a hyperlink below.

Practical 1: The class browser and Object
Practical 2: Creating Lefty
Practical 3: left method for Lefty

Figure 11.5: Showing the text at the start of Session 1: Creating a class in LB15.

To provide a common point for studying students' behaviour in their arrangement and use of windows, Practical 1 in LB15 was analysed for each user to determine how students organised their workspace. This practical would also show students' behaviour when dealing with the request for an additional window as it is suggested there that students also detach a third window to study the *Class Browser* (Figure 11.6).

Practical 1: The class browser and Object

The Subclasses section is organised in a similar fashion to previous chapters: with a class browser, a workspace and an amphibian world graphical user interface. The workspace and the amphibian world are exactly as you have become accustomed to, but the class browser is somewhat different. Click on the class browser tab and detach the page. Under the Class scrollable pane you will see the familiar `Account`, `Frog`, `HoverFrog` and `Toad` classes with `HoverFrog` indented beneath `Frog` to indicate that it is a subclass of `Frog`. However, you will also see that the class browser shows an additional class, `Object`, and that all the other classes are indented to indicate that they are subclasses of `Object`. Select `Object` and read through the text that appears in the main viewing pane.

With `Object` still highlighted, select in turn the `inspect`, `changed` and `updateUserInterfaces` methods from the scrollable pane and read the comments that describe them.

Discussion 1

Figure 11.6: Showing the content of Practical 1 asking students to detach the Class Browser as a third page.

This is of particular relevance to students who use a 800 x 600 screen resolution as it is impossible for them to be able to view all three windows together. How students dealt with this requirement was of additional interest.

Recordings information on window placement

In the recordings, information on the placement of each window, when it is moved or resized, is captured as a line starting with the tag `bounds` (Figure 11.7).

```
bounds:rectp164p77p636p523 window:i0/LB-15 Subclasses
```

Figure 11.7: Showing an example line taken from a student's recording in LB15. Time and date stamp information have been omitted for clarity.

This information is followed by encoded information on position, size of the window (`rectp164p77p636p523`) and the window identification (`window:i0`). In the recordings, window identification works on the basis that the window students are presented with is named Window i0 (`window:i0`), and each subsequent new window is identified sequentially from this. So, the next window to be created (as recommended in the instructions) would be identified as Window i1 (`window:i1`) and so on. The label or title as would be seen in the title bar of the window is also given following the window identification. If a window is closed, the next window to be detached is still labelled sequentially. Detaching a page can only be done from the initial window (Window i0).

The absolute position of the window is given in pixels and can be seen in Figure 11.7 as a series of four numeric sequences following the letter 'p' (`rectp164p77p636p523`). These give, in sequence, the distances of the left, top, right and bottom borders respectively, as measured from the left and top borders of the screen. So in Figure 11.7, Window i0 is 472 pixels wide by 446 pixels high, with its left border positioned at 164 pixels across from the left hand side of the screen and top border 77 pixels down from the top if the page. This is the location and size of all the initial LB windows.

Analysis was carried out using formulae developed in Microsoft Excel© to highlight those rows in the text which included the `bounds` tag as well as extract the information on window size, placement and identification so that an accurate image of each window's placement could be built up.

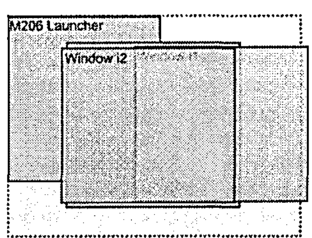
Users screen resolution

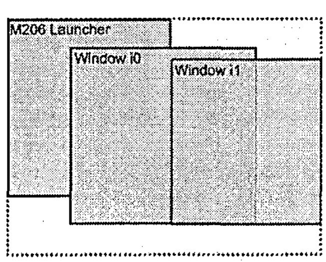
Information on the screen resolution students used was also taken into account as this affects the amount of available space for placing windows. The resolution that students used was obtained from the CGDQ and information was available for all 15 who had submitted a recording for LB15. 8 students used a screen resolution of 800 x 600 pixels, 5 used a screen resolution of 1024 x 768 pixels, 1 used a screen resolution of 1151 x 864 pixels. The remaining student (ID4) had answered in the CGDQ that they used a screen resolution 1024 x 768, but it was determined from window placement that their screen resolution was more consistent with a 1280 x 1024 pixel screen resolution, as their workspace arrangement would have been impossible at the lower resolution (this is graphically demonstrated later in Table 11.4).

Table 11.2, Table 11.3 and Table 11.4 show the workspace environments that each student set up at the start of the session organised by the screen resolution they used. The screen space available to each user is a shaded area surrounded by a dotted line. For consistency, all diagrams are drawn to the same scale. Because it is possible that window placement could also be influenced by a student's visual or verbal preference, the normed visual and verbal preferences as well as performance as measured by the Overall Exam Score (OES) and the Overall Continuous Assessment Score (OCAS) are given for each user for comparison.

Users of 800 x 600 screen resolution

Table 11.2: Details of users' workspace environment in Practical 1, LB15 when using a 800 x 600 pixel resolution screen. Additional details of visual and verbal preference and performance scores also given. All diagrams are to the same scale.

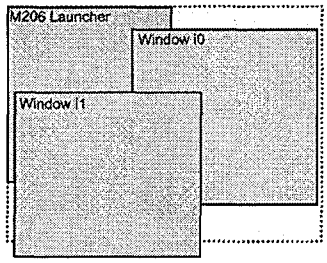
<table>
<tr><th>User</th><th>Workspace arrangement</th><th>Individual behaviour and characteristics</th></tr>
<tr><td>ID1</td><td>
</td><td>Visual: Very High
Verbal: Moderate
OES: 79
OCAS: 92.3

Behaviour: Window i1 detached with practical text in and moved to right hand side. Class browser detached as Window i2 but left in default location.</td></tr>
<tr><td>ID5</td><td>
</td><td>Visual: High
Verbal: Moderate
OES: 66
OCAS: 68.9

Behaviour: Window i1 detached with practical text. Window i1 then resized and moved to right hand side. Does not detach a third window, but uses tab in Window i0 to view class browser.</td></tr>
</table>

Table 11.2: Details of users' workspace environment in Practical 1, LB15 when using a 800 x 600 pixel resolution screen. Additional details of visual and verbal preference and performance scores also given. All diagrams are to the same scale.

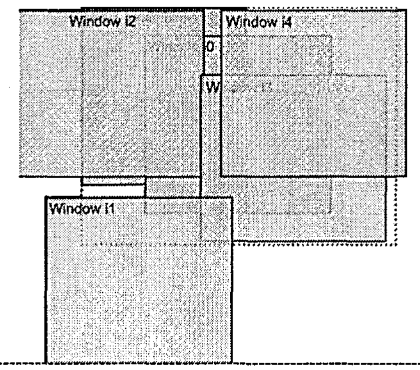
ID6



Visual: Very High
Verbal: Very High
OES: 95
OCAS: 96.6

Behaviour: Opens workspace, detaches as new Window i1, moves window to lower left corner. Moves window i0 to right hand side. No practical text viewed, but views class browser in tab in Window i0. Opens practical text later in new window, which is resized and moved to overlay the Launcher window.

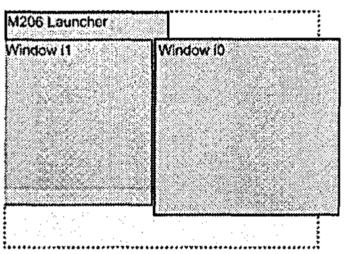
ID9



Visual: Moderate
Verbal: Very High
OES: 76
OCAS: 86.3

Behaviour: Detaches and creates 5 different windows at start. Opens the notes page rather than practical text in Window i1. Window i1 and Window i2 are moved off screen. Class browser is already open in window i4. Moves Window i1 to centre of screen to read at points during session then moves back again.

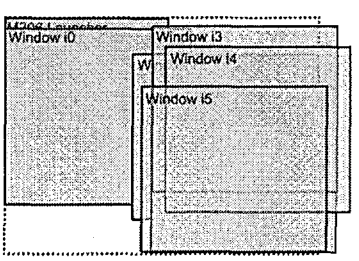
ID10



Visual: Low
Verbal: Moderate
OES: 71
OCAS: 85.6

Behaviour: Practical text in Window i1 detached. Windows i1 and i0 arranged as tiles. Does not detach a window, but uses tab in Window i0 to view class browser.

ID12



Visual: Very High
Verbal: High
OES: 63
OCAS: 72.9

Behaviour: Detaches and creates 5 different windows at start including suggested window. Text in Window i0. Views class browser in already open window i3

Table 11.2: Details of users' workspace environment in Practical 1, LB15 when using a 800 x 600 pixel resolution screen. Additional details of visual and verbal preference and performance scores also given. All diagrams are to the same scale.

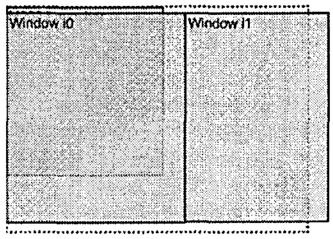
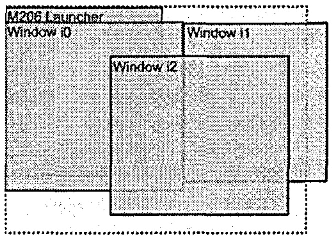
ID14		**Visual**: Moderate **Verbal**: Moderate **OES**: 89 **OCAS**: 87.0 **Behaviour**: Detaches practical notes as Window i1, arranges Windows i0 and i1 side by side with right hand tool button bar of window i1 off screen. Does not detach a window, but uses tab in Window i0 to view class browser.
ID15		**Visual**: Very Low **Verbal**: Moderate **OES**: 82 **OCAS**: 90.7 **Behaviour**: Detaches practical text as window i1, arranges Windows i0 and i1 side by side. Then opens and detaches the notes page as Window i2. Does not detach a window to view class browser, but uses tab in Window i0.

Table 11.2: Details of users' workspace environment in Practical 1, LB15 when using a 800 x 600 pixel resolution screen.

Users of 1024 x 768 screen resolution

Table 11.3: Details of users' workspace environment in Practical 1, LB15 when using a 1024 x 768 pixel resolution screen. Additional details of visual and verbal preference and performance scores also given. All diagrams are to the same scale.

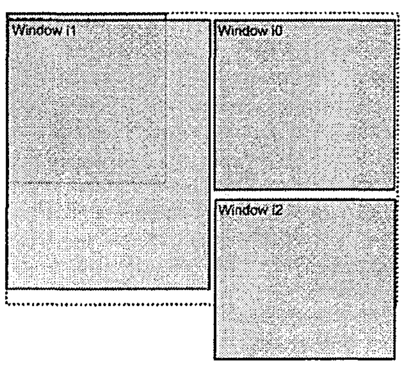
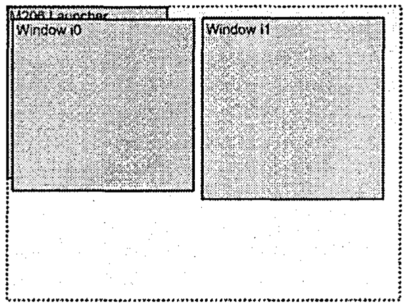
User	**Workspace arrangement**	**Individual behaviour and characteristics**
ID2		**Visual**: Moderate **Verbal**: High **OES**: 91 **OCAS**: 91.1 **Behaviour**: Detaches practical text as window i1, resizes and arranges side by side with Window i0. Detaches the GUI World (window i2) resizes and places below Window i0. Does not detach a Window to view class browser, but uses tab in Window i0.

Table 11.3: Details of users' workspace environment in Practical 1, LB15 when using a 1024 x 768 pixel resolution screen. Additional details of visual and verbal preference and performance scores also given. All diagrams are to the same scale.

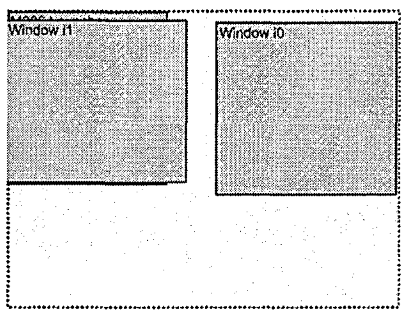
ID3



Visual: Moderate
Verbal: High
OES: 81
OCAS: 90.3

Behaviour: Detaches practical text as Window i1, resizes and arranges side by side with Window i0. Does not detach a window to view class browser, but uses tab in Window i0.

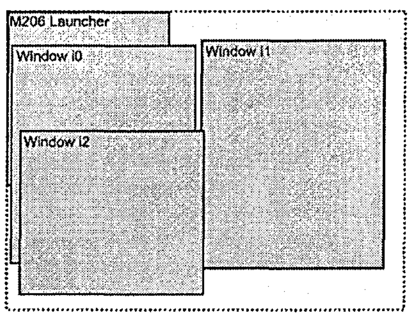
ID7



Visual: Very High
Verbal: Very High
OES: 76
OCAS: 89.4

Behaviour: Detaches practical text as Window i1, resizes and arranges side by side with Window i0. Does not detach a window to view class browser, but uses tab in Window i0.

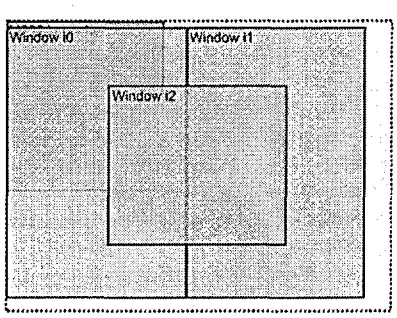
ID8



Visual: Moderate
Verbal: Moderate
OES: 52
OCAS: 78.3

Behaviour: Detaches practical text as Window i1, resizes and arranges side by side with Window i0. Detaches the class browser page (Window i2) and positions to left of text when asked.

ID13



Visual: High
Verbal: Moderate
OES: 83
OCAS: 90.3

Behaviour: Detaches practical text as Window i1, resizes and arranges both windows side by side. Detaches the class browser page (Window i2) when asked and leaves in default/opening position.

Table 11.3: Details of users' workspace environment in Practical 1, LB15 when using a 1024 x 768 pixel resolution screen.

Users of other screen resolutions

Table 11.4: Details of users' workspace environment in Practical 1, LB15 when using higher resolution screens than 1024 x 768 pixels. Additional details of visual and verbal preference and performance scores also given. All diagrams are to the same scale.

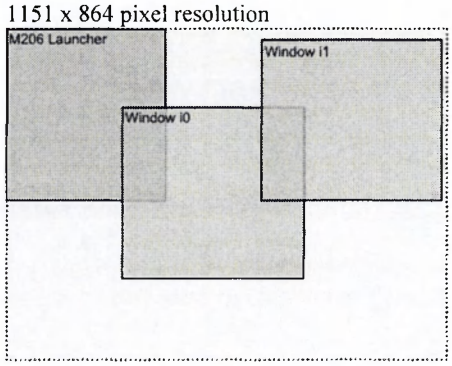
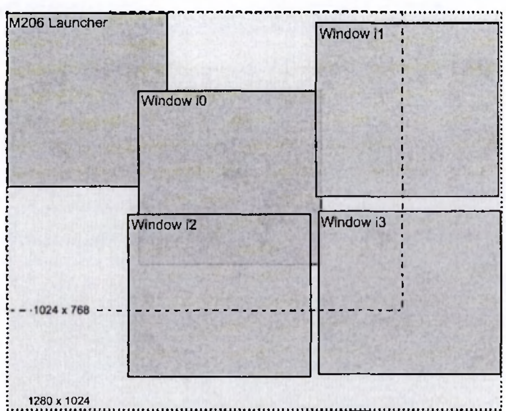
User	Workspace arrangement	Individual behaviour and characteristics
ID11	1151 x 864 pixel resolution 	**Visual**: High **Verbal**: High **OES**: 72 **OCAS**: 83.3 **Behaviour**: Detaches practical text as Window i1, positions in top right corner. Does not detach a window to view class browser, but uses tab in Window i0.
ID4		**Visual**: High **Verbal**: Very Low **OES**: 83 **OCAS**: 90.3 (Note arrangement of windows and content not visible if suggested resolution of 1024 x 768 used) **Behaviour**: Practical text detached as Window i1 and moved to top right corner, Workspace detached as Window i2 and class browser as Window i3. Examines the contents of class browser in its already open window.

Table 11.4: Details of users' workspace environment in Practical 1, LB15 when using screens of higher resolution than 1024 x 768.

All students were found to arrange their workspace environments at the start of the LB and then work their way through the practicals without changing the relative placement of the initial windows. For example, if they had stacked windows they would bring the required window to the front of the stack rather than move it to another location. The main exception to this was one student (ID9) who tucked two windows to one side of the screen so they only partially showed. ID9 would then bring these to the middle of the screen to use, then move them back to the side of the screen. Students who did not open further windows would use any available tabs or the menu within a window to navigate to new sections as they worked their way through the LB.

Students were also noted to arrange their workspace in the same way as they had before in each subsequent session carried out in LB15. A session is the period between a student opening a LB then closing it (discussed in Chapter 3).

In Practical 1, the text asks students to "Click on the class browser tab and detach the page". Table 11.5 summarises the student's responses to this request. Table 11.5 shows that 14 students examined the class browser, but only 3 of these students examined the class browser in a new window as suggested, the other 11 students either examined the class browser in an already open window or viewed it as a separate tab without detaching it. The remaining student (ID9) did not use the practical text window and instead used a customised text file in the *Notes* page. Because it is not possible to read the text in the *Notes* page, one cannot ascertain whether she was in Practical 1. However, although ID9 was noted to use the class browser, her activities were not consistent with the instructions in the practical and so it was assumed that she did not carry out this activity.

	Normed Visual Preference	Normed Verbal Preference	Screen resolution	Class Browser viewed in:
ID1	Very High	Moderate	800 x 600	New Window
ID2	Moderate	High	1024 x 768	Tab
ID3	Moderate	High	1024 x 768	Tab
ID4	High	Very Low	1280 x 1024	Already open window
ID5	High	Moderate	800 x 600	Tab
ID6	Very High	Very High	800 x 600	Tab
ID7	Very High	Very High	1024 x 768	Tab
ID8	Moderate	Moderate	1024 x 768	New Window
ID9	Moderate	Very High	800 x 600	Not viewed - but class browser used.
ID10	Low	Moderate	800 x 600	Tab
ID11	High	High	1151 x 864	Tab
ID12	Very High	High	800 x 600	Already open Window
ID13	High	Moderate	1024 x 768	New Window
ID14	Moderate	Moderate	800 x 600	Tab
ID15	Very Low	Moderate	800 x 600	Tab

Table 11.5: Table showing the choice of behaviour by students when asked in LB15 Practical 1 to examine the class browser. 'New Window' is the expected behaviour.

It is of interest that the majority of students carried out the requested task, even those who had already opened the class browser and other tabs as new windows at the start.

However, no relationship between students' behaviour in respect of workspace arrangement and screen size or visual and verbal preference could be found.

There was also no apparent behaviour that distinguished between those students who had performed the most poorly academically (ID5, ID8 and ID12) from those students who had better academic performance.

Study 1 - Discussion

The way students arrange their surrounding working environment is in itself a learning style (Dunn and Dunn, 1978); and in this small study students were found to use a variety of window arrangements including stacking, tiling, smart tiling (placing open windows side-by-side, but arranging windows so that irrelevant portions such as un-required tool bars were allowed to overlap or be hidden off screen) or a mix of these. However, students' arrangements were not affected by screen size and did not appear to affect performance or be related to a preference on the visual or verbal styles.

One possible reason for not finding any common behaviours relating to performance is that the small group is within itself relatively homogenous on the performance scale and that a different set of behaviours may be found in students who had failed. All students within this group organised their materials before starting work, suggesting that they had developed a habitual way of arranging their workspace and therefore found an arrangement that suited them. This is supported by the observation that students used the same arrangement in later uses of LB15. Although students were noted to be consistent in their arrangement of their workspace in LB15, an area for further study would be to see if this is consistent across other LBs and whether there is a point at which students develop this habit.

An aspect of how users arrange their windows that is of interest to courseware and program designers is the increased demands placed on working memory by stacking windows, as users who stack windows (where the content of any windows underneath the one on top are not visible) are more reliant on working memory (Reason, 1984; Baddeley, 1987; 1990; 1992) to hold information about the content of those windows no longer visible. Those who tile windows (place them side by side) are not reliant on working memory to hold this information. This is supported in work by Bly and Rosenberg (1986), who found that in some circumstances tiling was more effective than stacking and disproved the general belief held at the time that stacking windows one on top of each other was better. However, Hutchings et al (2004), in their work on the difference in window placement between users with multiple monitors and single monitors, reported that there was little work in the field that actually looked at how users arranged windows to produce the desired display effects and that more work still needed to be done.

A subsequent question is whether those who opt for stacking or tabbed arrangements have a greater working memory capacity than those who prefer a tiled arrangement. However, the arrangements could also be dependent on the task and the available materials so that in different online environments students might arrange windows differently, and what is seen is more consistent with Reason's (1984) model of working memory where working memory capacity is finite, but, like a mass of clay on a checker board of tasks, can be concentrated on one or two tasks or spread out over several. However, the more spread out it becomes, the less working memory there is available for a particular task. More in-depth studies looking at students' working memory capacity and window placement may prove beneficial in helping identify those students who are using their working space inefficiently.

Another aspect worth considering is that although there were no apparent links noted between students' choice of workspace arrangement and their visual and verbal preferences on the $QVVS_{Eng}$, the visual questions on the questionnaire measure visualisation from memory and it may be that a different visual construct, such as spatial ability, is of greater relevance. This is also an area for future work.

It was mentioned earlier that it was not known whether students had other window applications running at the same time as the LB, as the Recorder does not record anything outside of the LearningWorks environment. However, students' usage of windows suggests that other applications were not being used but it would be useful to monitor this in future studies using a recording tool capable of logging all window events such as VibeLog (Hutchings et al., 2004). The use of other windows outside the LearningWorks environment would also help indicate whether there are any common tools that students use that are not part of the LearningWorks environment.

Study 2 - Students' use of the notes page.

An additional finding of interest from Study 1 concerned students ID9 and ID15, as both of these were found to have used the *Notes* page while other students had not. However, ID9 and ID15 were also identified as having a stronger preference for the *Verbal* style over *Visual*, than other students. The relevance of this is that the *Notes* page (Figure 11.2b) is a blank page for students to make their own notes on. It was hypothesised that those students who had a greater preference for *Verbal* over *Visual* style were more likely to take advantage of this resource. The aim was also to answer the more general questions of when do students use the notes page as a resource and what do they use it for?

Indentification of notes use in recordings

The start of the session using LB15 entitled "Subclasses" for user ID15 is presented in Figure 11.8.

Formulae to identify *Notes* page usage were developed in Microsoft Excel© and used to gather a more detailed analysis of what activity was taking place in the *Notes* page. Those events where the *Notes* page was accessed were tagged and identified in the recording using the window or tab title. For instance "`...window:i2/LB-15 Subclasses: Practicals and Notes: Notes`" (as seen in lines 21 - 24) indicates that (reading right to left) the *Notes* page in the *Practicals and Notes* section for LB15 entitled "Subclasses" was used and is Window i2 (the second window that was detached).

Results

It was found that throughout LB15 only ID9 and ID15 used the notes page, but each in different ways.

iD15

After setting up the *Notes* page ID15 would frequently access it mainly after carrying out a practical. The *Notes* page would be accessed either after using the discussion that follows the practical instructions or from an activity page such as the *Workspace* or *Class Browser*. However, ID15 was noted frequently to copy text just before entering the *Notes* page and this was sometimes pasted while within the page. Copying of text was also noted within the *Notes* page. Unfortunately the Recorder is not set up to record what is pasted or copied in any window and also does not record anything typed in the *Notes* page, so it is not possible to determine what material was selected during these activities and what the content within the *Notes* page was. Some clue to content may be gained from the page previously accessed to the *Notes* page and from any text pasted afterwards into the *Workspace* to be evaluated, or into the *Methods*.

Line	**Original Log of Events**	**Notes Tag**	**Window in use**	**Window detached**	**Description of activity**
1	openUserVersion:false		**Open**		Opens LB15
2	bounds:rectp164p77p636p523 window:i0/LB-15 Subclasses				
3	detachPage			**D**	Detaches *Practicals* text (Window i1) and arranges position on screen.
4	bounds:rectp164p91p636p510 window:i1/LB-15 Subclasses: Practicals and Notes: Practicals				
5	bounds:rectp164p91p636p510 window:i1/LB-15 Subclasses: Practicals and Notes: Practicals				
6	bounds:rectp292p97p764p516 window:i1/LB-15 Subclasses: Practicals and Notes: Practicals				
7	bounds:rectp292p97p672p516 window:i1/LB-15 Subclasses: Practicals and Notes: Practicals				
8	bounds:rectp444p96p824p515 window:i1/LB-15 Subclasses: Practicals and Notes: Practicals				
9	bounds:rectp444p96p824p515 window:i1/LB-15 Subclasses: Practicals and Notes: Practicals				
10	enter:i0/LB-15 Subclasses		**i0**		Goes back into i0
11	bounds:rectp2p41p474p487 window:i0/LB-15 Subclasses				Moves Window i0
12	enter:i1/LB-15 Subclasses: Practicals and Notes: Practicals		**i1**		Enters *Practicals* text and arranges
13	bounds:rectp454p45p834p464 window:i1/LB-15 Subclasses: Practicals and Notes: Practicals				
14	bounds:rectp471p42p851p461 window:i1/LB-15 Subclasses: Practicals and Notes: Practicals				
15	bounds:rectp471p42p851p461 window:i1/LB-15 Subclasses: Practicals and Notes: Practicals				
16	enter:i0/LB-15 Subclasses		**i0**		Enters Window i0
17	tab:i2 'Notes'	**Notes**			Selects the *Notes* page tab
18	enter:i1/LB-15 Subclasses: Practicals and Notes: Practicals		**i1**		Enters *Practicals* text.
19	enter:i0/LB-15 Subclasses		**i0**		Enters Window i0
20	detachPage			**D**	Detaches *Notes* page and arranges new window on page.
21	bounds:rectp164p91p636p510 window:i2/LB-15 Subclasses: Practicals and Notes: Notes	**Notes**			
22	bounds:rectp164p91p636p510 window:i2/LB-15 Subclasses: Practicals and Notes: Notes	**Notes**			
23	bounds:rectp277p129p749p548 window:i2/LB-15 Subclasses: Practicals and Notes: Notes	**Notes**			
24	bounds:rectp277p129p749p548 window:i2/LB-15 Subclasses: Practicals and Notes: Notes	**Notes**			
25	enter:i0/LB-15 Subclasses		**i0**		Enters Window i0
26	tab:i1 'Practicals'				Selects Practicals tab and follows menu to the Subclasses
27	MENU Label for "/Subclasses'				
28	section:Subclasses				
	....				

Figure 11.8: Excerpt from the beginning of the recording for ID15 in LB15 identifying events where the Notes page was accessed, the window in use and when a page was detached. Time and date stamps for each event are omitted for clarity.

The Recorder is designed to record the activities within the *Workspace* and *Methods* pages so that when a recording is replayed, the LearningWorks environment on the machine used to replay the recording is updated and able to execute any new code, methods and classes created by the student. On the occasions when text was pasted into the *Workspace* or *Methods*, it was noted that this was programming code.

It is possible to determine what practical text was available to the student at each event involving the notes page. This was compared with ID15's activities, but the use of the *Notes* page did not follow any instructional text. From the type and sequence of activities it is surmised that ID15 used the notes page to supplement the text available and would also use it to make a note of code mentioned in the discussion pages or code he had found that had worked.

ID9

Similar to ID15, ID9 accessed and arranged the *Notes* page, however she used this window in a different way, importing the file "LB15.txt" into it at the start. The contents of this file are unknown as it is not a standard file supplied with the course materials. However, the ".txt" extension implies that the content would be text and ID9 was noted to use and refer to the notes window in a similar way that the other students would with the *Practical* page (Figure 11.2a). ID9 was also copied and pasted text on three occasions from the *Class Browser* (Figure 11.3c) into the *Notes* page, but did not copy any text from within the *Notes* page and the use of copying and pasting was much less than ID15 (ID9 = 7 copy events as opposed to ID15 = 60 events).

It was decided to expand the study to look at other LBs to determine if the common behaviours exhibited by ID9 and ID15 were repeated there. However, a consideration here was that the observed behaviour may have been in response to the type of material in LB15 which allows students the opportunity to develop their own code. Looking for other LBs with similar material, LB14 was chosen as it was the earliest LB in which ID9 and ID15 had complete records, and the LB also had a similar content to LB15. LB20 was also chosen as it is the first LB a little further into the course that has similar content to LB15.

Results

Table 11.6 details the findings of the investigations.

Student	Use of Notes in LB14	Use of Notes in LB15	Use of Notes in LB20	Visual preference	Verbal preference
ID1	No	No	No	Very High	Moderate
ID2	No	No	No	Moderate	High
ID3	No	No	No	Moderate	High
ID4	Yes	No	No	High	Very Low
ID5	No	No	No	High	Moderate
ID6	No	No	Yes	Very High	Very High
ID7	No	No	Yes	Very High	Very High
ID8	Yes	No	No	Moderate	Moderate
ID9	No	Yes	Yes	Moderate	Very High
ID10	No	No	No	Low	Moderate
ID11	Yes	No	No	High	High
ID12	Yes	No	No	Very High	High
ID13	No	No	No	High	Moderate
ID14	No	No	No	Moderate	Moderate
ID15	No	Yes	No	Very Low	Moderate

Table 11.6: Detailing students' use of notes in LBs 14, 15 and 20, with preferences on the visual and verbal learning styles provided for comparison.

It was found that the pattern was not repeated in other LBs and it was not consistent for any student except for ID9 between LB15 and LB20. Although in LB20 the three students who used the notes page were those who had a very high preference for the *Verbal* learning style, the *Notes* page usage does not appear to follow any individual preferences for being *Visual* or *Verbal.*

A more detailed analysis of what students were using the notes page for was carried out by examining the activities taking place before and after the *Notes* page was accessed. An example of this is given in Figure 11.9.

Apart from ID9, the other students in LB14 and LB20 who accessed the *Notes* page either spent time within it or were found to copy and paste text to and from an active window into the *Notes* page. This suggests that these students used the *Notes* page to hold code and information for later use.

Although ID9 did not use the *Notes* page in LB14 she did use it again in LB20 and this was noted to be similar to LB15 in that a text file was opened within the notes page and used instead of the practical notes.

Line	Original Log of Events	Date & Time	Description of activity
	....		
38	enter:i1/LB-14 New Behaviours: Answers and Arguments: Practicals and Notes: Practicals	03/10/2001 14:36:57	Enters Window i1 practical text
39	selectAnchor:c14s1d1.htm	03/10/2001 14:36:57	Selects hyperlink to Discussion 1. Spends 14 secs. in window.
40	enter:i0/LB-14 New Behaviours: Answers and Arguments	03/10/2001 14:37:11	Enters Answers and Arguments (Window i0)
41	select: Frog in: classList	03/10/2001 14:37:12	Looking at Frog, colour position and HoverFrog as suggested in class and methods lists.
42	select: colour in: methodList	03/10/2001 14:37:14	
43	scroll:p0p18 in:methodList	03/10/2001 14:37:18	
44	scroll:p0p18 in:methodList	03/10/2001 14:37:19	
45	scrollVertically:n90 in:methodList	03/10/2001 14:37:24	
46	scrollVertically:p0 in:methodList	03/10/2001 14:37:24	
47	select: position in: methodList	03/10/2001 14:37:24	
48	select: HoverFrog in: classList	03/10/2001 14:37:32	
49	select: height in: methodList	03/10/2001 14:37:33	
50	MENU Label for 'Behaviours'/'Practicals and Notes'	03/10/2001 14:37:40	Selects notes page in Window i0 remains there for 59 secs.
51	section:Practicals2and2Notes	03/10/2001 14:37:40	
52	tab:i2 'Notes'	03/10/2001 14:37:41	
53	enter:i1/LB-14 New Behaviours: Answers and Arguments: Practicals and Notes: Practicals	03/10/2001 14:38:40	Returns to discussion.
54	scrollVertically:n360 in:htmlView	03/10/2001 14:39:18	Scrolls
55	scrollVertically:p0 in:htmlView	03/10/2001 14:39:18	Scrolls
56	selectAnchor:c14s1p2.htm	03/10/2001 14:39:18	Selects hyperlink to next practical.
	....		

Figure 11.9: Excerpt from the recording for ID8 in LB14 identifying events in the excerpt where the Notes *page was accessed and activities surrounding it. In this example this is the first instance of ID8 using the* Notes *page.*

Study 2 - Discussion

8 students (53%) were found to have used the *Notes* page within LBs 14, 15 or 20. It was not possible to discern any pattern of *Notes* page usage, but it is quite possible that

the factors governing *Notes* page usage is determined differently for each LB. It would be interesting to find out why students decide to use this online resource at some points, but not at others, as this could give an insight into what types of resources and help students like to have available while studying independently.

An initial approach to this would be through the use of direct observation and interviews focussed on these questions. These resources were not available to this study, and this suggests the need for a similar study to be carried out as a way of determining the direction further investigation should take.

This study also highlights a limitation in the design of the Recorder in that it only records a limited set of activities in the *Notes* page, namely scrolling, copying and pasting. If the opportunity came to redesign the Recorder it would be useful to have the faculty to record what items were selected and copied, and what was typed within the *Notes* pages. These changes to the Recorder would not however have helped in determining the *Notes* page content in the case of ID9 who in LBs 15 and 20 opened a text file within the page and then referred to the file contents instead of referring to practical pages.

ID9 was the only student in this sample to be observed using the *Notes* page in this way and not using the practical pages. Because there is no information on what the content in the *Notes* page was, it is only possible to speculate on ID9's use of the materials. ID9 never accessed the practical instructions and it is assumed that ID9 therefore used the text that was displayed in the *Notes* page instead. One conjecture is that the text displayed was a compilation of the practicals and discussions into one file so that ID9 would have been able to view all material in one location and discussions and practicals could be viewed together as opposed to being on different pages.

ID9's behaviour is also something direct observation and interviews would provide useful insight into and to be considered in future work. This could be done through the initial replay of recordings then asking those students whose behaviours were of interest to participate in an interview.

Study 3 – Students' use of the practical text.

How do students use the practical text while studying M206? This analysis addresses the question by examining the sequence that students take with the practical and discussion pages in the instructional text.

Practical text in M206

The online material in M206 is arranged so that each practical is followed by its relevant discussion giving the expected answers on a separate page. Practical and discussion text are provided as HTML files viewed within the *Practical* page of the LB and accessed via embedded hyperlinks within each HTML file or from a drop down content menu on the *Practical* page. AESOP records both of these methods of access and the HTML file requested.

Identification of practical and discussion usage

All practicals and discussions have their own HTML files, accessed by following hyperlinks or use of the drop down menu, which are registered by the Recorder as the event `selectAnchor` followed by the file name of the HTML file. An example of this is seen in Figure 11.9 in line 39 and is reproduced below.

```
selectAnchor:c14s1d1.htm
```

Each HTML file is encoded following the sequence, LB number (`c14`), Section number (`s1`), practical or discussion number (Discussion 1 = `d1`). Using this information, formulae in Microsoft Excel© were developed to extract and identify the sequence that students used to work through the practicals in LB15.

Study 3 - Results

All students were found to work their way through LB15 in the sequence set by the course and carry out the practical instructions first before looking at the discussion. Students were also observed to return and use the *Workspace* after reading the discussion. An example of this is seen in Figure 11.9.

Information from the *Activist* scale on Honey and Mumford's Learning Styles Questionnaire and from the *Participant* scale on Grasha and Riechmann's Student Learning Style Scales was obtained for each student from their responses to these questionnaires in the 2001 study as each scale has constructs that relates to a preference for active learning. The results of the findings in comparison with students' expressed preferences on these scales are given in Table 11.7. Normative values compared to the Open University distance education population are used.

Student	Practical or Discussion first	Participant	Activist
ID1	Practical	High	Very Low
ID2	Practical	High	Very Low
ID3	Practical	Moderate	Moderate
ID4	Practical	Moderate	Moderate
ID5	Practical	High	Moderate
ID6	Practical	Very High	Low
ID7	Practical	High	Moderate
ID8	Practical	Moderate	Very Low
ID9	(N/A)	Moderate	Moderate
ID10	Practical	Moderate	Moderate
ID11	Practical	Moderate	Moderate
ID12	Practical	Moderate	High
ID13	Practical	Moderate	Moderate
ID14	Practical	Low	Moderate
ID15	Practical	High	Very Low

Table 11.7: Detailing students' use of practical or discussion pages first in comparison with expressed preference for Honey and Mumford's Activitist style and Grasha and Riechmann's Participant style.

Data for ID9 was not available as she had not used the HTML practicals or discussion files as discussed in Study 2. However, from the information available there does not appear to be any relationship between students' preferences for carrying out a practical first and expressed preference on either the *Participant* style or *Activist* style.

Study 3 - Discussion

It was unexpected to find that all students followed the course material in its suggested sequence. However, there are several possible reasons for this that need be explored further:

Previous Open University experience

All students in this study had previous experience of Open University courses and therefore are aware and experienced in the presentation structure of Open University courses. Although it is possible that, for a proportion of these students, their previous Open University courses would not have involved an online teaching element, they would nonetheless be aware of the expectation of following the course structure. However, this poses a number of questions:

- Do all M206 students follow the course structure for all LBs?

- If the course structure is not followed, what are the characteristics of the student and for LB in which this happens?

- Are there other distance education courses where students are more likely to not to follow a set course structure?

These are all questions worth investigating as they give a better insight into creating a better experience for students. In a larger sample of students, comparing those who are taking M206 as their first Open University course against other students who are taking

M206 as a second or later course, are any students noted to not be following the course structure and can it be established why? This could also be extended to other courses for other faculties where it is possible to monitor whether students follow course structure and to see if this common across the Open University or whether is limited to certain subjects or faculties.

Linear arrangement of pages

It was noted that the individual practical and discussion HTML files were arranged in a linear sequence, such that the only hyperlink present at the end of each practical and discussion page led on to the next page in the sequence. Access to previous pages or other pages out of sequence was possible, but to do so required students to make the additional step of either selecting the requested page from the drop down menu above it, or using the back button on the menu to return to a previously visited page.

It was not possible to determine within this study how much, if at all, this influenced students into following the course structure. However, as a subject for further investigation it would be worthwhile to see if students are less likely to follow the course structure if a different mechanism for accessing the pages was presented to them, such as having an always-visible Windows Explorer type directory.

Active and passive learning

Another possible explanation for the observed behaviour is that of active and passive learning. The issue of active and passive learning has a particular relevance to distance education because of its unique nature and the lack of presence of a teacher as would happen in normal face-to-face classroom environment. This is reflected in comments made by Arbaugh (2004) who states that for a successful transition for students to move from classroom to an online distance learning environment, instructors need to shift roles from providing knowledge to being a content facilitator. This in turn requires students to change from passively receiving to actively constructing and generating their own learning. However the change for students who may previously had experiences as passive learners in a recipient role in classroom settings can be a significant adjustment (Arbaugh, 2004), particularly if the passive style of learning suits them, so it may be a role they find hard to relinquish (Thompson et al., 2004).

In the sample examined in the present study, all students followed the presented course structure. If it is surmised that active and passive learning is related to this behaviour then another possibility to the ones already discussed is that all the students in this sample are active learners.

Further studies looking at different courses and at different levels have already been mentioned as being useful for determining the extent to which students follow the course structure. However, it would also be useful to extend these studies to other distance education courses and different pedagogical approaches to test out whether students do take a passive learning role and under what circumstances.

General Discussion

How students arrange their workspace onscreen is of interest to cognitive psychologists, courseware and software designers because of the cognitive implications in having various screens visible or not visible. In M206, students have the opportunity to arrange windows according to their own preference, but other educational programs do not necessarily offer students the same freedom to arrange their workspace. The cognitive implications of lack of freedom could influence students' performances. In addition, the variety of screen resolutions being used, even within this small sample, indicates that courseware and software designers need to keep this in mind when designing programs, particularly any that are dependent on the resolution of the monitor. Despite the relative importance of this, it is interesting to note that Hutchings et al. (2004) report that few studies have been undertaken that actually look at the *mechanics* of screen placement, where 'mechanics' is defined as being "how users arrange windows to produce the desired display effects.".

In addition to the relevance of their work on window arrangement, Hutchings et al's paper is of interest here for their description of VibeLog, an application built in C++ which behaves in much the same way as the Recorder but works on any Windows platform and which, in addition to recording users' activity, also records information such as system configuration.

Spatial ability was not measured in this study. However, as stacking involves a spatial arrangement there may be a relationship between an individual's spatial ability and whether that individual prefers to stack windows or not. A review of the questions on the $QVVS_{Eng}$ indicates that the visual construct looks at visual imagery and ability to recall items visually, rather than the spatial construct which has been identified as being separate to visual recall (Kozhevnikov et al., 2002). Although no relationship between window arrangement and visual preference was found, the ability to recall information visually and therefore what the content is of windows that are hidden, may be of more relevance than spatial ability or there may be an interaction between the two.

All the students were noted to follow the course structure in its specified order. Several reasons for this were postulated. One reason that needs be explored in depth is the extent to which the linearity of the M206 course presentation discourages students from taking alternative routes. However, all students in this study were noted to be returning Open University students with experience of at least one previous course. The importance of this is that courses at the Open University encourage students to follow the suggested learning sequence and become active learners. A larger scale study looking at first time Open University distance education students would provide useful information on the prevalence of passive learners at the start, and a study of students on other distance education courses with different pedagogical approaches would help to gauge how much the pedagogical approach used encourages students to be active. If it were found that those learners who had a stronger preference for passive learning had a difference in performance or greater drop out rates, this would be of interest to designers of the pedagogical material as it has implications for the design of adaptive courseware to meet these students' needs.

Further work

The objective of the small studies in this chapter has been to investigate and explore behaviours that AESOP records in relation to the ways that students learn. The results of these investigations have generated a number of questions deserving further exploration. These are:

- Do students use the same window placements in different LBs in M206?
- Do students use the same window arrangement in subsequent sessions of other LBs?
- If individual students do not use a consistent method of arrangement, what are the characteristics of the student and the LB in which the arrangement differs?
- Is there a relationship between working memory and window placement? Does this have any affect on performance? Would a student with poor working memory capacity who stacks windows have a better performance, if they were taught to arrange their workspace more advantageously, for example tiling?

- What relationship exists between students' spatial ability and how they organise their workspace? Do students who have greater spatial ability arrange their windows in a different way to those who have poor spatial ability? What factors influence the ways they use or arrange their workspace?
- Do students use other programs at the same time as studying M206? What programs are being used and what are they being used for?
- What proportion of students follow the M206 course-structure? What are the characteristics of those students who follow the course-structure and of those that do not.
- What are the proportions of students following the course-structure in other distance education courses?
- What proportion of students starting Open University courses or other distance education courses are passive learners? Does this differ from students choosing to enrol in more traditionally taught classroom settings?
- Why do students use the *Notes* page resource at some points and not others? Are there any resources that students need that are not being provided?
- Do students who fail the M206 course exhibit different behaviours to those who pass?

Conclusion

15 (6 Female, 9 Male) students were observed in a series of fine grain analyses of their behaviour, looking at window arrangement, the use of the *Notes* page as a tool, and the sequence in which they used the practical text. Students in this sample were identified as being relatively homogenous in performance, all getting above 50 in their Overall

Exam Score and not failing, all having prior experience with the Open University, and there was a good representation of both genders.

From the observations made in these studies, students were seen to demonstrate a range of behaviours even within the small sample, but there are some commonalities. The most notable of these is that the majority of the students (14 out of 15) followed the practical instructions and also followed the expected pattern of undertaking a practical, then reading the following discussion before moving on to the next practical. Further study of a larger sample would be required to determine just what percentage of all students follow the practical instructions routinely, and how much this is related to the way the material is structured or whether this is related to students being active learners.

There was no consistent relationship in the way that students used the *Notes* page when observed over a series of LBs (LB14, LB15 and LB20) although these LBs had been selected for similarity of task. The content of what was written or added to the *Notes* page was not recorded by the AESOP Recorder. However, students were noted to paste lines of programming code into other pages after using the *Notes* pages. Further work is required to find out what the *Notes* page is being used for.

Screen resolution and visual and verbal preferences were examined for relationships with the way that students arranged their working environment in LB15, but there were no relationships found. Students were noted to use a number of ways of organising their workspace, including tiling, stacking and smart tiling. All students were noted to arrange their windows workspace at the start of a practical session and then work their way through the LB leaving this arrangement relatively unchanged. The style and arranging the workspace at the start of a sitting (period of time when they worked on the LB) was also noted to be consistent through the LB. Further work is planned for looking at whether the same arrangements are used in other LBs and the relationship with workspace arrangement with other factors such as spatial ability and working memory.

This study has shown that AESOP is able to record a number of behaviours of interest and that even with the small sample looked at there are a range of behaviours exhibited with information of interest to course and software designers.

Chapter 12.

Comparison of Pre- and Post-Study Learning Style Preference

Abstract

Students' pre- and post-study preferences for the learning styles on the Grasha and Riechmann Student Learning Styles Scales (Riechmann and Grasha, 1974; Grasha, 1996a), the Learning Styles Questionnaire (Honey and Mumford, 1986; Honey, 1991; Honey and Mumford, 1995), and an English adaptation of Antonietti and Giorgetti's Questionnaire of Visual and Verbal Strategies (Antonietti and Giorgetti, 1993) were compared. There were no significant changes between pre- and post-study distributions, but the results were suggestive of increased preferences for the *Independent* and *Avoidant* styles post-study. The implications for the design of distance education courses are discussed.

Introduction

In the 2001 study discussed in Chapter 9, three different learning style questionnaires were used: the Learning Styles Questionnaire (Honey and Mumford, 1986; Honey, 1991; Honey and Mumford, 1995), the Grasha and Reichmann Student Learning Styles Scales (Riechmann and Grasha, 1974; Grasha, 1996a) and an English adaptation of Antonietti and Giorgetti's Questionnaire of Visual and Verbal Strategies (Antonietti and Giorgetti, 1993), discussed in Chapter 8. It is generally accepted that individuals' preferences for learning styles are capable of changing over time (Honey and Mumford, 1995; Grasha, 1996a; Graham, 1997; Liu and Ginther, 1999). Honey and Mumford (1995) base their Learning Styles Questionnaire (LSQ) on the expectation that users will work to develop those styles they are weak in. The preferences examined by the Grasha and Reichmann Student Learning Styles Scales (GRSLSS) are in comparison regarded as being more stable, but nonetheless mutable depending on whether a student receives a consistent teaching method that was biased towards a particular style (Grasha, 1996a). For visual and verbal styles, the current evidence indicates that although most people can switch between visual and verbal strategies according to the nature of the task, the ability of individuals to do so appears to be heavily dependent on their cognitive ability in these styles (Richardson, 1977; Baddeley, 1987; 1990; 1992; Antonietti and Baldo, 1994; Antonietti and Colombo, 1997; Lang et al., 1999).

To assess the impact of the course on students' preferences for the learning styles discussed above, a repeated measures design was employed in the 2001 study with those students who had returned pre-study questionnaires being approached later in the course and invited to complete the same questionnaires.

Method

The methodology for the collection of data is the same as discussed in detail in Chapter 9. All responses to the questionnaires were scored according to the normative data obtained in Chapter 6, for distance educations students at the Open University and on the five point scale used for the Learning Styles Questionnaire (Honey and Mumford, 1986; Honey, 1991; Honey and Mumford, 1995).

Results

Return rate

46 students (females = 21, males = 25) completed the three pre-study learning styles questionnaires. Of the students who completed the pre-study questionnaires,

17 (females = 8, males = 9) responded to the second request and completed post-study questionnaires.

Comparability of Post-study group with Pre-study group

Those who had completed both the pre- and post-study questionnaire (pre-post group) were compared against those who had only completed the pre-study questionnaire (pre-only) to measure the comparability of the two groups. Comparisons of the demographic profiles between the two groups are given in Table 12.1 and Table 12.2.

		Group		Total
		Pre- only	**Pre-post**	
Gender	Female	13	8	21
	Male	16	9	25
Total		**29**	**17**	**46**

Table 12.1: Cross-tabulation comparing gender by those returning the post-study questionnaire and those who did not (Mann-Whitney U = 241.00, Z = -0.175, $p_{exact} = 1.000$*).*

		Group		Total
		Pre- only	**Pre-post**	
Age group	Under 20	1	0	1
	21 - 25	0	1	1
	26 - 30	6	3	9
	31 - 35	5	2	7
	36 - 40	7	5	12
	41 - 45	7	2	9
	46 - 50	2	3	5
	51 - 55	0	1	1
	61 - 65	1	0	1
Total		**29**	**17**	**46**

Table 12.2: Cross-tabulation comparing age group by those returning the post-study questionnaire and those who did not (Mann-Whitney U = 229.0, Z = -0.394, $p_{exact} = 0.591$*).*

Because the number of post-study cases is less than 20, the use of Chi-Square for analysis is regarded as being unreliable (Lane, 2001). In addition, as the two groups for this comparison are regarded as being independent of each other the Mann-Whitney U was used instead (*SPSS for Windows,* 2002).

No differences in distributions were found between the pre-post group and pre- only group with regard to gender (Mann-Whitney U = 241.0, Z = -0.145, p_{exact} = 1.000) and age (Mann-Whitney U = 229.0, Z = -0.394, p_{exact} = 0.701). This indicates that the pre-post and pre- only groups were of similar distributions.

The differences in academic performance on Overall Exam Score (OES) and Overall Continuous Assessment Score (OCAS) between both the pre- only and pre-post groups were also explored. Two students were excluded from the OES analysis as there was no data available for them. Results of the independent t-test carried out between groups are given in Table 12.3. No significant differences were found on either measure of academic performance indicating that both the pre- only and the pre-post groups were comparable on these measures.

	Group	**N.**	**Mean**	**sd.**	**t**	**p**
OES	Pre- only	27	68.56	28.14	-1.312	0.197
	Pre-post	17	78.12	12.96		
OCAS	Pre- only	29	84.60	9.39	0.031	0.976
	Pre-post	17	84.51	9.93		

Table 12.3: Independent t-test comparing academic performance on exam (OES) and assessed work (OCAS) measures between students who completed the pre and post-study questionnaire and those who completed only the pre-study questionnaire.

Differences between groups in the pre-study learning styles were explored to see if the pre-post group were also representative on these characteristics. Comparison was again carried out using the Mann-Whitney analysis because of sample size. Cases were excluded on a case-by-case basis where students had no data for certain styles, either through not completing one of the questionnaires or missing questions out. Results of the comparisons are given in Table 12.4, Table 12.5 and Table 12.6.

	Group	N	Mann-Whitney U	Z	Exact Sig. (2-tailed)
Activist	Pre- only	28	233.5	-0.112	0.915
	Pre and Post	17			
	Total	**45**			
Reflective	Pre- only	28	226	-0.297	0.778
	Pre and Post	17			
	Total	**45**			
Theorist	Pre- only	28	200.5	-0.608	0.547
	Pre and Post	16			
	Total	**44**			
Pragmatist	Pre- only	28	213	-0.604	0.556
	Pre and Post	17			
	Total	**45**			

Table 12.4: Results of Mann-Whitney tests of independence between the pre- only and pre-post groups for the styles on the LSQ.

The pre-post group were found to be not significantly different from the pre- only group on any of the styles on the LSQ. However, on the $QVVS_{Eng}$ the pre-post group were found to be significantly different from the pre- only group on the *Visual* learning style (Mann-Whitney U = 131.0, Z = -2.433, p = 0.014). On the GRSLSS, the *Dependent* learning style was also found to be significantly different between the two groups (Mann-Whitney U = 156.5.0, Z = -2.193, p = 0.029).

Effect size for both of these significances was calculated using point estimation calculated as part of the Mann-Whitney routine in MINITAB® (2005), suggested by Garthwaite (2005). The effect size for both the *Visual* and *Dependent* styles was subsequently found to be 1.00, suggesting that the difference between the two distributions is 1 category. These differences in distributions are shown graphically in Figure 12.1 and Figure 12.2.

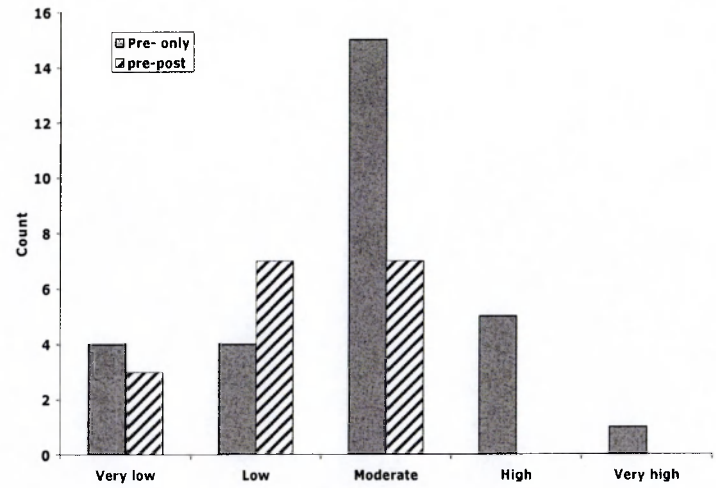
	Group	N	Mann-Whitney U	Z	Exact Sig. (2-tailed)
Visual	Pre- only	27	131	-2.433	0.014
	Pre and Post	17			
	Total	**44**			
Verbal	Pre- only	27	190	-1.007	0.312
	Pre and Post	17			
	Total	**44**			

Table 12.5: Results of Mann-Whitney tests of independence between the pre- only and pre-post groups for the styles on the $QVVS_{Eng}$.

	Group	N	Mann-Whitney U	Z	Exact Sig. (2-tailed)
Avoidant	Pre- only	29	194.5	-1.226	0.225
	Pre and Post	17			
	Total	**46**			
Independent	Pre- only	29	225.5	-0.500	0.628
	Pre and Post	17			
	Total	**46**			
Collaborative	Pre- only	29	242.5	-0.096	0.934
	Pre and Post	17			
	Total	**46**			
Dependent	Pre- only	29	156.5	-2.193	0.029
	Pre and Post	17			
	Total	**46**			
Participant	Pre- only	29	214.5	-0.776	0.451
	Pre and Post	17			
	Total	**46**			

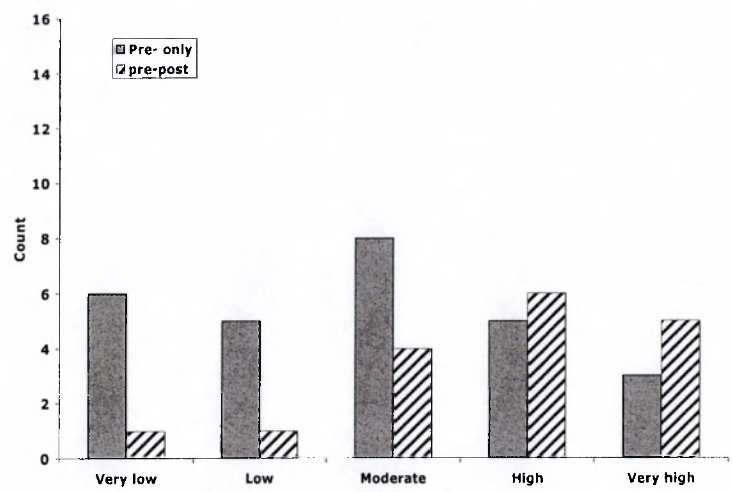
Table 12.6: Results of Mann-Whitney tests of independence between the pre- only and pre-post groups for the styles on the GRSLSS.

Figure 12.1 and Figure 12.2 show that the pre-post group have a greater preference for the *Visual* learning style than the pre- only and also are less *Dependent*. It was not determined from this data why students were significantly different on either style and further work needs to be done to determine the nature of these relationships. One such relationship could be related to the attribute of little intellectual curiosity commented to be part of the *Dependent* style (Grasha, 1996b). It may be that students who take part in surveys in general are intellectually more curious and therefore those who are more curious are more likely to take part in follow up studies. However, the distribution of preferences for the pre- only group shows a distribution approximating a normal distribution, which is not skewed towards a lesser preference. This suggests that the above hypothesis is not necessarily true.



Dependent

Figure 12.1: Showing the difference in distributions of the pre- only and the pre-post group on the Dependent learning style.



Visual

Figure 12.2: Showing the difference in distributions of the pre- only and the pre-post group on the Visual learning style.

Comparison of Individuals' Pre-study and Post-study Learning Style Preferences

To observe if students preferences for any of the learning styles studied had changed over the duration of the course, the responses of individuals who had responded to the post-study questionnaire were compared to their pre-study preferences on each style. Pre-study and post-study frequency distributions were calculated for each style.

Changes in distribution were analysed using Wilcoxon Signed-Ranks Test, suitable for small numbers, and comparing the magnitude and direction of change (Weisstein, 1999; *SPSS for Windows*, 2002; Vanson, 2005).

Learning Styles Questionnaire

17 students returned post-study data for the four styles in the Learning Style Questionnaire (LSQ). One student was excluded from analysis on the *Theorist* style, as they had not completed all the questions on the pre-study questionnaire relating to this style.

Table 12.7 presents the frequency distribution of students' preferences for both pre-study and post-study responses on the styles of the LSQ. Table 12.8 summarises the magnitude (number of levels changed) and direction (positive = increased preference, negative = reduced preference) of change by students from their pre- to post-study preferences.

			Level of Preference				
Style		N	**Very Low (1)**	**Low (2)**	**Moderate (3)**	**High (4)**	**Very High (5)**
Activist	Pre-Study	17	3	3	9	2	0
	Post-Study	17	5	3	5	4	0
Reflector	Pre-Study	17	3	5	7	1	1
	Post-Study	17	4	2	7	3	1
Theorist	Pre-Study	16	0	6	7	1	2
	Post-Study	16	1	3	8	2	2
Pragmatist	Pre-Study	17	4	0	5	6	2
	Post-Study	17	3	3	4	3	4

Table 12.7: Pre- and post-study frequency distributions of students' preferences for styles on the Learning Style Questionnaire.

It can be seen in Table 12.8, that in all four styles a number of individuals have changed preferences, but there is no consistency in the direction on any of the styles. This was confirmed with the Wilcoxon Signed Ranks Test showing that none of these changes were significant.

	Magnitude of Change					Wilcoxon Signed Ranks	
	-2	-1	0	1	2	Z	p_{exact} (2-tailed)
Activist	2	3	8	3	1	-0.491	0.750
Reflective	0	2	11	3	1	-1.000	0.531
Theorist	1	2	7	6	0	-0.577	0.781
Pragmatist	1	4	6	6	0	0.000	1.000

Table 12.8: Showing the direction and magnitude of changes from pre-study to post study on each style of Learning Style Questionnaire. The Wilcoxon Signed Ranks Z statistic and significance level are also described for each style.

Grasha-Reichmann Student Learning Styles Scales

16 students returned post-study data for the styles in the Grasha-Riechmann Student Learning Styles Scales (GRSLSS). Two more students were excluded from analysis on the *Independent* style, as they had not completed all the questions on the post-study questionnaire relating to this style.

Table 12.9 presents the frequency distribution of students' preferences for both pre-study and post-study responses on the styles of the GRSLSS. Table 12.10 summarises the magnitude (number of levels changed) and direction (positive = increased preference, negative = reduced preference) of change by students from their pre- to post-study preferences.

			Level of Preference				
Style		N	**Very Low (1)**	**Low (2)**	**Moderate (3)**	**High (4)**	**Very High (5)**
Avoidant	Pre-study	16	4	6	4	2	0
	Post-study	16	2	6	4	2	2
Collaborative	Pre-study	16	1	5	7	3	0
	Post-study	16	2	4	8	2	0
Dependent	Pre-study	16	3	6	7	0	0
	Post-study	16	6	4	6	0	0
Independent	Pre-study	14	1	2	9	2	0
	Post-study	14	0	4	7	2	1
Participant	Pre-study	16	1	2	7	4	2
	Post-study	16	3	3	5	3	2

Table 12.9: Pre- and post-study frequency distributions of students' preferences for styles on the Grasha-Riechmann Student Learning Style Scales.

	Magnitude of Change							Wilcoxon Signed Ranks	
	-3	-2	-1	0	1	2	3	Z	p_{exact} (2-tailed)
Avoidant	0	0	3	6	4	2	1	-1.642	0.131
Independent	0	1	1	8	3	1	0	-0.541	0.781
Collaborative	0	0	3	12	1	0	0	-1.000	0.625
Dependent	0	0	4	12	0	0	0	-2.000	0.125
Participant	0	2	4	8	2	0	0	-1.613	0.172

Table 12.10: Showing the direction and magnitude of changes from pre-study to post study on each style of Grasha-Riechmann Student Learning Style Scales. Wilcoxon Signed Ranks Z statistic and significance level are also described for each style.

There were no significant changes noted for any of the styles. The pre- and post-study distribution frequencies for the *Dependent* and *Collaborative* style are both very similar to each other with only 25% (4 students) in each exhibiting a mostly negative change in preference. On the *Independent* style, 4 students changed positively, but 2 students also changed negatively. There is a mixed movement also on the *Participant* style with 2 students indicating a positive change but a greater proportion (6 students) were noted to be less *Participant* than before. The greatest number of students indicating a change in preference from before on the *Avoidant* scale, with 3 students indicating less preference for being *Avoidant*, however, 7 students indicated being more avoidant. In the case of one student this was a large change over 3 categories from having a Low preference to a Very High preference.

Questionnaire of Visual and Verbal Strategies (English)

17 students returned post-study data for the styles in the Questionnaire of Visual and Verbal Strategies (English)($QVVS_{Eng}$).

Table 12.11 presents the frequency distribution of students' preferences for both pre-study and post-study responses on the styles of the $QVVS_{Eng}$. Table 12.12 summarises the magnitude (number of levels changed) and direction (positive = increased preference, negative = reduced preference) of change by students from their pre-study preferences to post-study.

Style		N	Level of Preference Very Low (1)	Low (2)	Moderate (3)	High (4)	Very High (5)
Verbal	Pre-study	17	3	1	7	4	2
	Post-study	17	3	3	5	5	1
Visual	Pre-study	17	1	1	4	6	5
	Post-study	17	1	1	5	9	1

Table 12.11: Pre- and post-study frequency distributions of students' preferences for styles on the Questionnaire of Visual and Verbal Strategies (English).

	Magnitude of Change							Wilcoxon Signed Ranks	
	-3	**-2**	**-1**	**0**	**1**	**2**	**3**	**Z**	**p_{exact} (2-tailed)**
Verbal	0	0	6	9	1	1	0	-0.905	0.563
Visual	0	0	8	6	3	0	0	-1.508	0.227

Table 12.12: Showing the direction and magnitude of changes from pre-study to post study on each style of Questionnaire of Visual and Verbal Strategies (English). Wilcoxon Signed Ranks Z statistic and significance level are also described for each style.

For the *Visual* style the pre- and post-study distributions are very similar. However, this belies the fact that 11 of the students (65%) indicated a change in visual preference, and most of these changed to being less visual; the effect size was also relatively large (Z = -1.508). The *Verbal* style also demonstrates a similar pattern with 8 students (47%) indicating a change in preference. Of these, 6 students expressed lower preference for the verbal style. A Wilcoxon Signed Ranks analysis found these changes for both the *Visual* and *Verbal* style were not significant.

Discussion

An important consideration with this work is the concept of *magnitude* that is used in this chapter. Magnitude is based on categorical levels of preference and used to measure not just whether a student's preference changes, but by how many categories. These categories in turn are based on the normative data of other Open University distance education students and therefore subject to the differing levels of sensitivity between the individual scale's raw scores and the subsequent categories.

An example of this can be seen in the normed data for the Visual and Verbal styles (Table 12.13) where, if a student had previously scored 22 on the visual scale and in the post-study analysis improved their score by 8 to 30, they would have been shown as having improved from having a Low preference to a Moderate preference. However if they had scored 21 previously on the visual scale and changed their score by 8, this would have indicated an improvement from a Very Low preference to a Moderate preference.

Given that there is this level of variability with magnitude, it is interesting to note that although there were no significant changes found in the overall distribution patterns of the students between their pre-study and post-study, there were a number of students who had apparently changed their preferences in style. However, because students were noted to change preference both positively and negatively this shows as no overall movement.

	Very Low Preference (Lowest 10%)	**Low Preference**	**Moderate Preference** (Middle 40%)	**Strong Preference**	**Very Strong Preference** (Highest 10%)
Visual	9 – 21	22 – 26	27 – 31	32 – 36	37 – 45
Verbal	7 – 17	18 – 20	21 – 25	26 – 28	29 – 35

Table 12.13: Normative data for the Questionnaire on Visual and Verbal Strategies (English) based on a sample of 181 distance education students, using categories as set out by Honey and Mumford (1995)

There were no significant net gain found on any of the learning styles between the pre and post- study. Effect size was not calculated for these as the calculation of effect size in these cases is meaningless (Garthwaite, 2005).

That there was no demonstrable change in any one direction suggests that the individual differences seen between the pre-study and post-study preferences are a result of other factors including the test - retest reliability of the questionnaire and not an effect of the course or the materials on the students in this sample. Test-retest reliability is based on the assumption that no changes take place between the two instances of testing. This assumption is, however, affected by time, because the longer the interval between tests the greater will be the opportunity for external factors to influence an individual and their responses to a questionnaire or test. The time between the pre- and post-tests was between six and seven months so it would be reasonable to expect there to have been some influences over that time.

The lack of an observed general change does not preclude the possibility that the learning style preferences of some individuals were affected by the course, and this is another area of further study to identify which individuals are influenced by course content and the relationship the course content has with them and why. This would require identifying those individuals who appear to have been most affected and then identifying the common factors that distinguishes them from those who showed no change.

Two interesting findings were found when comparing the students who took part in the follow up and completed the post-study questionnaire against those students who had not taken part. In general, it was found that the two groups were comparable on age, gender and academic performance. However, on the learning styles, the follow-up group were found to have a significantly greater preference for the *Visual* style and significantly less preference for the *Dependent* style. It is conjectured that one possibility is an aspect of the *Dependent* style which is lack of intellectual curiosity (Grasha, 1996b), and an area for future study is to explore the relationship between intellectual curiosity, the *Dependent* style and willingness to partake in research work. As with the *Dependent* style, it can not be determined from this data why students who took part in the follow-up should differ significantly on the *Visual* style and it remains to be seen if a similar result can be duplicated with a larger sample and identifying any factors indicating the nature of the relationship.

Conclusion

17 students took part in the follow-up post-study survey of learning styles and were found to be comparable on the measures of gender, age and academic ability to those who had not taken part. However, the students who did take part in the follow-up were found to have an overall significantly greater preference for the *Visual* learning style and a significantly reduced preference for the *Dependent* style. It is possible that the latter might be due to the relationship between individuals' intellectual curiosity and the *Dependent* style something Grasha and Riechmann attributes as part of the style (Grasha, 1996b).

The pre-study and post-study preferences of those students who took part in the follow up study were compared. Students were found to improve or reduce their preferences on all the learning styles, but there was no significantly consistent trend in a single direction. A change in learning style preference could be related to course content for some students, but it is conjectured students' changes in preference are probably more through interactions with other factors not related to course content.

A larger scale study is required to allow for more robust statistical analyses to be carried out. However, the number of students changing their preference may also indicate that only certain students change their preference and future work is to identify those students who do change and the individual characteristics and factors that are related to those changes.

Chapter 13.

Further Discussion and Summary of Findings

"What is really important now, is to pass from empirical [experiential] approach to scientific-based and research-proven methods."

Osipova et al. (2001)

Abstract

This chapter reviews the main findings in relation to the research questions. Other implications of these and of the overall study are discussed along with a summary of findings.

Discussion

A growing number of universities internationally offer CBI-based distance courses. Charp (1999) reports that in 1999, more than 750 different distance education courses were being offered by over 300 universities in the United States of America. In the United Kingdom, the Open University, a distance education specialist, is regarded as Britain's major e-learning institution ('E-learning at the Open University,' 2003) with over 200,000 students enrolled. In 2003, 150 of the 360 Open University courses offered used information technology to enhance their material ('The Open University: Background Information,' 2003). The use of e-learning is also growing rapidly. In 2004, 30 Open University courses were 'online', with an additional 247 out of the 375 courses offered that year either requiring online access or allowing use of online services for the course ('E-learning at the Open University, Facts and Figures,' 2004).

The findings in this work, which add to the knowledge of how students study and use CBI materials, are of interest to educators, and to courseware and software designers.

They therefore have the potential to benefit future distance education students through the development of better CBI materials.

<u>Wider implications of findings with learning styles</u>

This research corroborates other evidence that individuals learn more effectively if the pedagogical material they are presented with matches their learning style (Dunn and Dunn, 1978; Grasha, 1996b; Montgomery and Grout, 1998). In this research, academic performance and the time taken to complete study material as measured by the *Total Active Time* (TAT), were found to correlate significantly with the *Activist* and *Theorist* styles on the Learning Styles Questionnaire (Honey and Mumford, 1986; Honey, 1991; Honey and Mumford, 1995) and with the *Collaborative* and *Dependent* scales on the Grasha and Riechmann Student Learning Style Scales (Grasha, 1996b; 1996a).

Although the Grasha and Riechmann Student Learning Style Scales, were designed for classroom teaching situations, these results indicate that they can be applied usefully to distance education.

The opportunity for interaction in distance education can be just as good or better than in the traditional classroom (Muirhead, 2000). However, in the same discussion by Muirhead, a study by Mason (1991) found that only one third of students taking part in an Open University distance education course were actively engaged in providing and receiving on-line feedback. Therefore, although there are opportunities for a tutor to interact with their students in distance education, there is a proportion of students who do not actively engage. Students who do not interact are less likely to have their needs detected by the tutor. This has a potential academic implication, since students who are *Dependent* need more guidance from the tutor (Grasha, 1996b; 1996a), but if students who are *Dependent* do not interact, they may not receive this guidance and therefore not do so well. In Chapter 9, the *Dependent* style was found to correlate negatively with academic performance. It is conjectured that students who are *Dependent* are the less likely to interact and therefore do not receive the guidance required through interaction with the tutor. This suggests the need to look at the characteristics of students who do not engage in the online interactions and to identify those characteristics that are related to performance. There is also the need to identify ways that tutors can use to encourage students to interact so the tutor has more opportunity to identify individual needs and provide learner support (Muirhead, 2000; Muirhead and Juwah, 2003).

Nonetheless, students who do not have access to a tutor on a distance education course are reliant solely on the instructional material to provide the support they need. The relationship found between learning styles and academic performance indicates the need for the development of software that can detect learning style preferences and adapt the learning environment to them. Adaptable computer based instructional (CBI) materials are a promising vehicle for delivering courseware where presentation is matched to the individual. The forms that this support, or adaptation, takes are a matter for future research.

In Chapter 9, some learning styles had significant interactions with academic performance and other learning styles with the time students took to complete the LearningBooks (LB). All the students in the research had ready access to the same CBI materials that were integral to the M206 course. The finding that some learning styles had significant interactions with performance indicates that the CBI material provided did not serve all students equally well. This corroborates similar findings by others (Kulik, 1994; Ross and Schulz, 1999) that not all CBI materials are able to meet the needs of all learners and supports the requirement for research into CBI materials that meet individual needs. In addition, these differences in learning style also suggest ways in which students' needs could be identified.

Discussion of Findings

<u>Do distance education students show a consistent time of day or day of the week that they work?</u>

The findings corroborate both of Bååth's (1982) observations, namely that (1) distance education students vary widely in the time they take to complete work and (2) they work at times that are convenient to them. This research also found that students did not work consistently on a particular day or period of the week (such as weekends or midweek). Students were, however, noted to have a preference for working predominantly at certain times of the day.

The pattern in the times that students start to work, as shown in Figure 3.7, is consistent with a number of lifestyle patterns. For example, students who have a regular daytime occupation are likely to study in the evening, and the results show higher numbers studying in the evening and a rise in the number of students starting to study at 5pm. Students who studied in the evening also showed less variability in the times that they chose to start studying, possibly indicating that they might have been more constrained in their available study times. A number of students were noted to commence study during the day, and this would fit in with those who don't have a typical 9-5 day profile, such as the unemployed, shift workers, those who work from home, and those who stay at home to care for family. The latter may account for the slump at around 15:00 to 16:00, consistent with children coming home from school. These are however conjectures needing further examination, requiring data about occupations and commitment patterns.

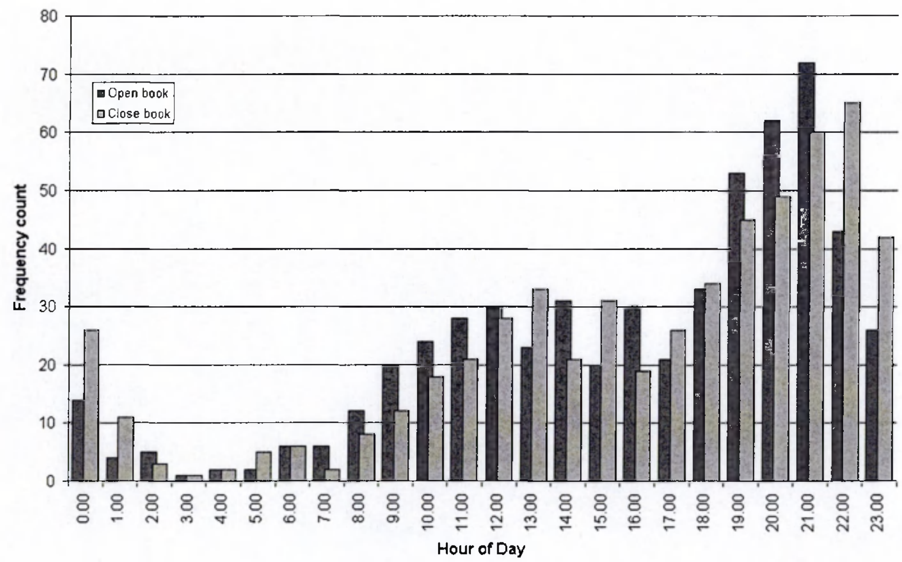


Figure 13.1: Frequency distribution showing participants usual (median) time for starting (Open) and finishing (Close) studying.

This research found that the time of day that students started to study was not related to their academic performance, but other studies (Folkard and Monk, 1978; Revelle and Loftus, 1992) have found that time of day can affect learning, memory and recall. If students are restricted in the times in which they can study, they may not be studying at times preferred or advantageous.

One implication is that, performance on other distance education courses with different material may be more influenced by the time of day at which the course is studied (such as those with greater reliance on long-term memory). If courses are found where students' performance on the course is affected by the time of day at which they study, this becomes relevant for courseware and educational software designers, with the need to identify methods of delivering the material so that the course is not susceptible to the time of day at which it is studied. Further work would also be desired to identify the characteristics of these courses and the design elements involved as this will have implications for design of future courses.

Another implication is that the number of students found to be working in the evening rather than earlier, suggests that course designers and providers may need to take this into consideration when looking at the best time to schedule time dependent resources, such as live broadcasts, conferencing, tutoring, support, etc.

<u>Does the degree of comfort with computing tasks that a student expresses at the start of a course relate to their use of CBI material?</u>

Comfort was found to be an important factor. Females were significantly less comfortable with computing tasks than males, except for using communication tasks. Further work is required to confirm the extent to which students expressed levels of comfort equate to confidence, but the findings are similar to previous research (Shashaani, 1994; Busch, 1995; Corston and Colman, 1996; Comber et al., 1997; Durndell et al., 2000) that females are generally less confident with computers than males. Students with prior knowledge of programming at the start of the course were significantly more comfortable with the task of programming than those without prior knowledge.

The finding that females were just as comfortable as males with communication, but not with other computing tasks, suggests that females taking the course may have more experience in the use of the communication software than in other tasks. This corroborates the suggestion by Nordli (1998), citing Turkle (1997), that females' interest in ICT is based on interactivity and communication rather than programming. Nordli also puts forward Turkle's (1984) assertion of hard and soft mastery in programming, where, *"hard mastery is a rational, step-by-step, preplanned programming strategy, while soft mastery is more of an artistic and interactive, trial-and-error type of approach."* Turkle also suggests that hard-mastery is preferred by males, although not all, while soft-mastery is preferred by females, but not all. This has a huge implication for how course designers could make courses more attractive to women, or an alternative way for delivering a programming course to meet individual needs.

Those students who were less comfortable at the start of the course took longer to complete practical work and did not do as well academically. In this study students levels of comfort were self assessed, however work by Rountree et al. (2001; 2002) also found that students' own predictions of performance was the best predictor. This suggests that students' levels of comfort at the start of the course could be a useful predictor of performance and therefore a possible way of identifying students with a greater need. However, students' levels of comfort with computing-related tasks improved over the duration of the course, such that the significant differences found at the start no longer existed at the end of the course. If students' levels of comfort are used they should therefore be measured at the start.

Do distance education students have a greater preference for specific learning styles over the general population?

In Chapter 8, a survey of 180 distance education students taking second level courses at the Open University found that this sample of distance education students has a different set of learning styles preferences than the published general population norms. Future research with distance education students needs to be aware of this and the characteristics of the population to which the research sample is being compared.

On the Learning Style Questionnaire, distance education students had a higher preference for the *Activist*, *Reflector* and *Theorist* style than the general public. On the Grasha-Riechmann Student Learning Style Scales, distance education students were found to have a greater preference for being *Collaborative*, *Independent*, *Avoidant* and

Participative. They also had a reduced preference for being *Dependent*. The *Competitive* style was not measured.

An open question for future research is whether these traits develop in distance education students as a result of interactions with the course materials, or whether these are the natural preferences for distance educations students, indicating that some types of students are more likely to take up distance education courses.

A longitudinal study surveying students just starting and later completing their courses (both distance and conventional) could address this question. One possible scenario is that students who do well and carry on to second level courses have a different range of preferences that do not change over the duration of the first course. If this is found to be the case one implication is that these characteristics thereby provide a possible indicator for identifying students who are likely to do less well.

<u>Is there a relationship between individuals' preferences for selected learning styles and their use of CBI material?</u>

In Chapter 9, LBs 09, 10, 12, 13, 14 and 15 were studied to explore this question. After correcting for students' levels of comfort, there was a significant negative correlation between the *Visual* style and the time taken to complete the practical work in LBs 12 and 14. In both these practicals, students are introduced to new features of the interface and guided in exploring them through carrying out tasks. One conjecture is that students who are more *Visual* spend longer exploring the interfaces. Another conjecture is that those students with strong visual tendencies require visual confirmation of the behaviour of objects from expressions they had just evaluated. However, visual confirmation would require students to use the *World* page, which is on a different page from the verbal materials (the *Workspace*). Unless a student arranges their environment to have the *World* (visual material) and *Workspace* (verbal material) visible at the same time, by placing windows side-by-side, the visual material is presented sequentially to verbal information. However, Mousavi et al. (1995) and Mayer (1997) both argue that multimedia materials should be presented concurrently. As AESOP records the pages that are accessed, this suggests that one area for future work would be to look at how students use the *World* page, and also to determine if rearranging the working environment improves performance.

The *Theorist* and *Collaborative* styles were both found to correlate significantly with the TAT in LBs 13 and 12 respectively. The *Visual* and *Verbal* styles were also noted to correlate strongly with the proportion of time-spent reading in LB13 (RTR). However, the correlations were not found in the other LBs examined. This lack of consistent findings has implications for the direction that future work should take, both for the method used and the theory behind it. This is discussed later in 'Implications for future work'.

<u>Do any of the factors of learning style, time or comfort relate to students' ability to learn as measured by their academic performance or time to complete tasks?</u>

Both the *Activist* and *Dependent* styles showed a significant negative correlation with students' final examination scores. The stronger an individual's preference for these styles, the greater their score for continuous assessment work would be compared to their examination mark. Those who had a strong *Activist* or *Dependent* style therefore appeared to be just as academically able with continuously assessed work as those who did not have strong preferences for these styles, but they were less successful in the examinations. Further research is required, as it may be that these styles could be used to recognize those who would benefit from material and training, either to improve their examination performance or to tailor the assessment to suit the individual.

Activist is a style on which Honey and Mumford encourage individuals to improve (Honey and Mumford, 1995) so individuals are proficient on all four stages of the learning cycle. However, being strong in this style is associated with a negative effect for the M206 distance education course. This suggests that the design of the M206 course does not meet the needs of those with a preference for the *Activist* learning style. The way in which the M206 course does not meet the need of those with an *Activist* preference is a matter for future work. This finding is also consistent with research carried out by Ross and Schulz (1999), who also found CBI material was not suitable for all types of learners.

If any factors are found to affect the use of CBI and noted to significantly affect a student's performance, is it possible to identify these factors/styles automatically and therefore for software to be automatically adaptive to meet individuals' needs?

There is a cost involved, both in time and money, in developing CBI. To the course designer, information about which individual characteristics affect academic performance and how strong these effects are will help decide the cost effectiveness of taking these characteristics into account when designing any CBI. In this study the individual characteristics noted to be related to learning outcomes were levels of comfort and, closely related to this, prior experience of programming, as well as the *Dependent* and *Activist* styles after students' levels of comfort had been controlled for. This work has only looked at one sample of students studying M206; so further work will be needed to see if these results are generalisable to rest of the M206 population and to what extent they might generalise to other courses.

Another consideration is that the sphere of influence of certain individual characteristics may be very specific to a course, but the impact of those characteristics within that course might be significant enough to need addressing. If this is the case, this supports the need for research to discover which students need the most help and as part of this process identify any individual characteristics which characterise them.

However, none of the individual characteristics of comfort, prior experience of programming, or *Dependent* and *Activist* styles were found to correlate to an online behaviour examined in this course. Nonetheless, this does not preclude the possibility of these characteristics correlating with other online behaviours. If a characteristic had been found to be related to an online behaviour, it would potentially provide a way to automatically detect it and therefore a way to individualise software to meet individuals' needs.

How do students arrange their workspace?

In Chapter 11, students were found to organise their workspace at the start of the session, and then leave the arrangement relatively unchanged for the remainder of the session. Students were also noted to use the same arrangement when opening the LB on different occasions. Arrangements used were tiles, stacking, smart tiling and these in combination.

One finding of interest was the variability in the way that students arranged their screens within the small sample analysed (N=15). There was no consistent relationship between the way that students arranged their workspace, their preference for the *Visual* or *Verbal* styles or for the screen resolution that students reported they were using. Interestingly, students had the common behaviour of arranging their workspace at the start and then leaving this arrangement relatively untouched. The additional observation that students used the same arrangement when they opened the LB on subsequent occasions suggests that students had already established a pattern of working.

Future studies looking at other LBs are required to determine at what point students develop this arrangement and whether it is consistent through all the LBs or whether other factors influence it, e.g., the increasing availability of different tools and pages which can be detached as new windows. The observation that some students had multiple windows opened also deserves further investigation as it raises the question of why some students prefer to have different windows open and stacked and others prefer to use the tabs within a single window. The answer to this may indicate better ways in which to present materials to meet students' needs and the design of better interfaces.

What do students use the **Notes** ***page for?***

The *Notes* page is a blank page with basic word processing tools that is part of the *Practicals and Notes* section and is for students to record their own notes. LBs 14, 15 and 20 were analysed to determine when and why students used this resource. Approximately half were found to use the *Notes* page at some point, but virtually none were consistent in their use. Only one student was observed to use the *Notes* page in two different LBs and it was observed that this student used the *Notes* page in a very different way from other students.

AESOP had limitations in its design, as it did not record the contents of the *Notes* page. What students used the *Notes* page for could only be conjectured from the activities taking place immediately before and after, such as cut and paste.

However, as half the students studied used this page, this suggests that more research needs to be carried out, looking at a larger sample, over more LBs and at the actual contents of the *Notes* page, to determine what students are using the page for. Two possibilities are the *Notes* page being used as a temporary area to compile different bits of code and/or creating a set of notes to be able to access later. Other questions to be answered include why use the *Notes* page in one LB and not another? Is this related to task?

It would be useful to draw comparisons with other courses which include an online notes page for students' use and to see to what uses, if any, they put these pages. The use to which the notes page is put could also be a possible indicator of those students who are actively learning rather than passive (Corno and Mandinach, 1983; Wilson, 1996; McManus, 2001), as it could show whether students are building their own notes and therefore constructing their own meaning from the material (Papert, 1993). The use to which students put these pages could also determine whether there are any resources that would improve the students' leaning experience.

Do students follow the expected course pattern?

The online practical text is delivered as a series of practicals, each followed by a corresponding discussion with the expected answers on a different page. Students can navigate to any of these pages directly, so that it possible to read the discussion first or to use only the discussion pages. In Chapter 11, all students, however, were observed to follow the presentation in the sequence set out, reading and carrying out the practical texts first, then reading the discussion and occasionally returning to carry out a task.

Although all students in this sample followed the suggested sequence, as this group was small and self-selected, there is the possibility that they were not representative of the course population. This pattern of working might be affected by other factors, such as time available to follow the course structure. This is something to be explored in a future study both to see what proportion of students follow the course sequence and to identify what factors, such as time available, are related to this.

One hypothesis explored was that all students might have been active learners (Wilson, 1996; McManus, 2001). This has not been proved, but students' preferences varied from Very Low to High for the *Activist* style and Low to Very High for the *Participant* style. This suggests that students had a mixed level of preference for being active learners. However, although both styles were selected for having concepts that were similar to being Active, Liu and Ginther (1999) and Coffield et al. (2004a) both cite work indicating problems with the construct validity of the *Activist* style.

Learning Style Changes

In Chapter 12, 17 students completed a follow-up survey of their learning style preferences six to seven months after starting the course. A proportion of students in each style did change in individual preference; these changes however, were both negative and positive, with no overall group change in preference. Students who took part in the follow-up survey were also compared to those who had completed the pre-study survey but did not complete the follow-up. The two groups were generally similar to each other in demographic and learning style preference distributions. However, those who completed the follow-up were found to have significantly greater preference for being *Visual* (Mann-Whitney $U = 131$, $Z = -2.433$, $p = 0.014$) and significantly less preference for being *Dependent* (Mann-Whitney $U = 156.5$, $Z = -2.193$, $p = 0.029$).

An attribute of the *Dependent* style is lack of academic curiosity (Grasha, 1996b), and it is conjectured that students who take part in surveys are less *Dependent* than the average distance education student against which these scales were compared (Chapter 6), but this requires further investigation. One way to do this is compare a group who volunteer for a survey with a group not given the choice, but this has ethical considerations.

The lack of an overall movement towards a greater or lesser preference on any style between the pre- and post-study surveys suggests that there was no overall group movement and that the course content had no effect on learning styles. However, this does not reflect the proportion of individual changes that took place in each style. Some of these changes were quite extreme, for example, one individual changed from a low *Avoidant* preference at the start to a very high preference at the end. These individual changes need to be looked at in much more detail. It is possible that the change seen in some individuals is related to the course content, but this relationship could be affected by interactions with other factors, such as previous experience of other courses, what other courses they may be taking at the same, the level of interaction with their tutor and peers and their tutor's own learning style preferences (Grasha, 1996b; 1996a)

General implications for future work

In addition to the results of the individual analyses, there are a number of general points related to the design of the research which are worth discussing here, as there are some useful implications for future work.

Methodological Implications

In the discussions about the TAT and RTR research, it has already been commented that rather than whole LBs being analysed, it may be more useful to look at smaller units, such as individual practicals. By looking at the whole LB, there are a number of levels of detail that become lost by information being lumped together. This could include differences between individual practicals such as pedagogic content or sequence, as students may be found to be consistently slower with the first practical in a LB than the last, or the other way around. However, by making the level of granularity finer, this introduces more factors, and the need for a greater number of sets of data for any statistical analysis of this to be robust, particularly if there is a possibility of interactions between several factors. There is therefore a pragmatic trade off between what the researcher wants to study and what can be studied.

An alternative approach is to also look at a single individual's behaviour, rather than at groups of individuals, as was done in the fine grained analyses in Chapter 11. This builds up a picture of how one or a few students use the materials, and therefore allows better questions to be developed. However, the findings may not be generalisable, and it is more time consuming than large scale studies looking at specific factors.

In this research both approaches were taken as the available data set was limited.

Individual characteristics

Another consideration is the learning styles that were examined. According to Coffield et al. (2004a; 2004b), some researchers think that a reliable and valid measure of learning styles has not yet been developed. Although the variability in the learning styles seen between the pre- and post-study assessments suggests there are potential issues with reliability and validity on the learning style scales, other factors, including the course content, cannot be ruled out as possible sources of influence.

One potential way of following this up is to identify if any students have changed their learning style preference directly in relation to the course content. However, another possibility is that the relationship between learning styles and course content may not be direct and that there are interactions with other factors, such as those previously discussed earlier under "Learning Style Changes".

Parallel to this is the similarly likely possibility that a learning characteristic will not be embodied in one single online behaviour, but be reflected as a collection of differences in online behaviours. Support for this view comes from the finding that a number of learning styles showed the same interactions with the same material. For LB12, three learning styles had positive correlations with the TAT. In addition, the levels of comfort (Chapter 4) expressed by participants for various computing related tasks were also shown to have small but significant correlations with TAT. While TAT can therefore be used as an indicator, it would have to be used in conjunction with other behaviours to identify specific learning styles. Additional support comes from the fine grained analyses and users' arrangement of their workspace, which indicate that, even if a learner had a preference for one arrangement over another, what can be observed is constrained by their physical environment. It would be interesting to see if students choose a different arrangement in a different physical environment.

Subjects

Another consideration is that these studies were carried out with students studying a university-level course. There is anecdotal evidence (Kambouri, 2004; Mellar, 2004) to suggest that learning styles have a greater importance for young learners or those at the basic skills level, who have not yet learnt or developed the ability to adapt pedagogic material to meet their specific learning style requirements, or to adapt their strategies to the material. Students at university level are likely to have had far more experience than basic needs students of different pedagogic styles and have had the opportunity to develop strategies for handling and processing these different types of material.

In view of this, the goal of software being able to automatically determine a user's learning style preference would also be of significance to students if, as part of the process, feedback was given to them about their learning style preference, what it means and how they can make use of this information. However, this needs to be a continuous and integral part of the learning process in order to be effective and of use to the student (Coffield et al., 2004b).

Another group of students who have not been addressed are those who failed or dropped out of the course. All the students examined in this data passed their exams. However, it is possible that students who failed or dropped out of the course have different individual characteristics that are relevant to their academic performance or choice to leave the course. It is also possible that this group of students displays very different behaviours in their use of the course materials and there is therefore a need to investigate these students' behaviour in future studies.

However, the practicalities of doing so need to be considered, as failing or dropping out behaviours are not pre-anticipated. Those students who do so may also be self-selecting in their choice to not take part in any voluntary research. Work by Rountree et al (2001; 2002) shows that one of the best predictors of a student's performance is themselves, so it is possible that students who predict that they will not do well will not feel inclined to take part. It is therefore necessary to find a way to encourage as many students as possible to take part in the research and have a mechanism in place to follow up those students who do drop-out, if there is any post-study data to be collected.

Contribution to research

In the field of CBI, particularly for distance education, the 'holy grail' is the provision of individualised instruction based on an individual's preferred learning characteristics. This research contributes to this quest by furthering the knowledge of online behaviours and how students learn, and suggesting ways forward.

Development of Measures and Instruments

In this research a number of measures were developed which are of interest for future research.

Total Active Time (TAT)

The TAT as described in Chapter 3, developed in collaboration with Thomas and Paine (2000b; 2002), provides a better estimate of the actual time that students spent working than past measures by excluding individual periods of non-activity exceeding 5 minutes. This approach to calculating the time that students spent actively working is also used by Hutchings et al. (2004), who independently chose a period of 5 minutes as their cut-off point for non-activity.

Reading Time Ratio (RTR)

The development of the RTR in Chapter 10 followed on from the development of the TAT. The interest was in looking at the specific behaviour of reading and how much of the TAT was spent carrying out this activity. However, it is possible to extend this concept easily to any other type of activity such as writing programming code or the use of a particular resource. Although the concept behind the RTR is to take into account the varying lengths of TAT students were noted to spend completing their work and to proportion the reading time as part of this, it is possible that the Total Reading Time (TRT) (Chapter 10) used to calculate the RTR, may be may be a more useful indicator by itself, an issue which needs to be explored further.

Computing General Demographic Questionnaire (CGDQ)

The CGDQ was developed as an online questionnaire to elicit answers to questions which AESOP could not record. These are questions on demographics (age, gender, occupation and post code), comfort with various computing tasks, programming experience and distance education experience and computing hardware configuration. The CGDQ was designed for use with AESOP, but it has potential as a supplemental tool for other research. However, some aspects of it require further development.

Students' level of comfort with computing is measured on the CGDQ via a series of questions asking how comfortable the respondent is with five aspects of computing: internet, email, programming, installing software and using software. Each of these is on a 5 point Likert-like scale. These questions needs further development to establish their validity and reliability including test-retest reliability and further work also needs to be done to see how this section can be improved. This includes 1) considering the wording used and whether the use of different wording, such as use of 'confidence' rather than comfort, produces significantly different responses. 2) The extension of this section to include greater discrimination of activities 3) The use of a linear scale instead of an ordinal one to measure respondents' levels.

Another future study is to compare the CGDQ to other confidence and anxiety scales, such as the Computer Anxiety Rating Scale (Rosen and Weil, 1992).

The questions on programming and distance education experience requested a binary "Yes" or "No" response, and included space for additional voluntary detail. The type of detail this elicits needs to be extended to draw out more precise information about the programming experience that students have had, such as what types of languages they have been using and length of time they have been using each one.

For the questions on hardware and software configurations, it is possible to use software that will automatically obtain the answers to these questions and this is worth looking into as a future development for AESOP or other similar tools. The advantage of this would be to shorten the number of questions students need to answer and by obtaining the information directly the possibility for human error is diminished.

Findings

This work has produced a number of findings leading to better questions.

- In Chapter 4, females at the start of the course were less comfortable than males in most computing tasks except for those involving communication. There was no difference in comfort at the end of the course.

- In Chapter 4, students who were less comfortable at the start of the course were noted to do significantly less well in the exams at the end of the course. In relation to this, students who had prior programming experience had a greater level of comfort at the start than those who had none.

- In Chapter 4, a third of the students with prior-programming experience expressed less comfort with programming after the course than before. It is conjectured that this could be due to a change in programming paradigm.

- In Chapter 6, a university wide survey of Open University distance education students taking a second level course found them to have a different distribution in their learning style preferences than the published norms for the general population on these scales. Norms for this population of distance education students are developed for the Learning Styles Questionnaire (Honey and Mumford, 1986; 1995) and the Grasha and Riechmann Student Learning Style Scales (Grasha, 1996b; 1996a).

- In Chapter 8, an English adaptation of the Questionnaire of *Visual* and *Verbal* Strategies (Antonietti and Giorgetti, 1993) is developed, the Questionnaire of

Visual Verbal Strategies (English) ($QVVS_{Eng}$). The norms for this are captured for the Open University distance education student population.

- In Chapter 9, controlling for students' level of comfort, the *Dependent* and *Activist* styles on the Grasha and Riechmann Student Learning Style Scales and the Learning Styles Questionnaire respectively were both found to have significantly negative correlations with students' exam performance. The *Theorist*, *Collaborative*, *Visual* and *Verbal* styles were also found to correlate to the TAT that students took to complete some LBs, suggesting further more detailed investigation.

- In Chapter 10, the concept of the RTR is developed and findings indicate that there are no predictable patterns between LBs in the time that students spend reading. In LB13, a strong correlation between the proportional amount of time spent reading and students *Visual* preference was found, suggesting that the time spent reading and its relationship with various learning styles, in particular the *Visual* style, is worth investigating further.

- In Chapter 11, in a series of fine grain analyses, students were found to use a variety of strategies to arrange their workspace including tiling, smart tiling, stacking and combinations of these. Virtually all students were found to follow the course sequence of practical first, then reading the related discussion. Half of the students were noted to use at some point the *Notes* page, an additional LB resource, to make notes or possibly as a temporary area to work. These behaviours all suggest further directions to explore how students use materials to learn.

Chapter 14.

Limitations, Implications and Further Work

Abstract

This chapter explores the main themes of the thesis its limitations, the importance of the work towards the development of CBI materials and looks at the various suggestions for further work from the studies.

Students' use of Computer Based Instructional materials.

The core theme of this research has been to investigate how various factors relate to students' use of CBI materials, that is, how individual characteristics such as experience and learning preferences relate to students' online behaviour and use of practical materials. To investigate this, students' behaviours were observed using AESOP (An Electronic Student Observatory Project) which allows the asynchronous, remote recording and playback of students' online activities in the LearningWorks environment as students study the Open University course *M206 Computing: An Object Oriented Approach* (*The Open University,* 1998b).

What could be studied using AESOP

AESOP was intended to provide a complete record of students' activities within the M206 learning environment. This includes their use of any of the learning materials or facilities, in activities ranging from reading texts through answering practical questions to generating and testing code. The intention was to provide complete playback for human viewing, as well as completely automated logging of events. The aim was to combine AESOP with custom filters designed by researchers to address particular research questions. Hence, the logging tools (Recorder) were provided, but for the most part the data compilation and analysis tools were left to future researchers.

However, there were some discrepancies between the intention and the realisation of AESOP, which put constraints on this research. Some behaviours were recorded fully and accurately by AESOP, such as time, sequence of events, window evocation and placement, and Learning Book page. Others, however, were less fully captured, such as detailed cut-and-paste of content, mouse usage and what users typed into the *Notes* window. As a result, this research addresses two classes of question, using different approaches:

- *Questions relating to time and performance* (for which there was complete and accurate data) - quantitative studies reported in Chapters 3, 9 and 10.

- *Questions relating to detailed behaviours* such as patterns of materials usage, sequences of cognitive activities and arrangement of work space within the learning environment (for which there was less comprehensive data, for fewer students) - qualitative studies reported in Chapter 11.

Time and performance

AESOP gives every event within the learning environment a time and date stamp. Time and date data were compared to performance, learning styles questionnaire responses, and background data from the CGDQ in order to address questions about the relationship between individual characteristics and general learning behaviours. These time-and-date investigations allowed us to draw useful conclusions about general behaviours, in particular about study patterns through the day. Such conclusions can be useful in planning distance education courses as they provide information about the best times to deliver materials such as live tutorials or conferences that are dependent on the time of day.

The time-and-date investigations provided little insight into specific uses of constituent course materials or into the kinds of learning and reasoning behaviours students demonstrate. Questions of this nature were addressed to a limited extent using a more exploratory, qualitative approach, as described below.

Detailed behaviours

Records of keyboard and screen events were interpreted in order to address questions about students' use of materials and sequences of activities. These fine-grained analyses allowed us to identify some patterns in the arrangements of displays and the conduct of course activities that may relate to performance or learning. These analyses are most useful in framing well-grounded questions for further research, including, "What implications does arrangement of workspace have on performance and working memory?", "What additional resources are required to provide a better learning experience?" and "Do those who fail or drop out, use the materials in a different way?"

The data sample was not broad or large enough to enable a comparison between those with good and poor academic performance, and so this is a matter for further study using the same protocol but a different and much larger sample of students. The limitations of the AESOP log did not allow examination of individual note-taking, again something for further study by including this functionality in future releases of the Recorder.

The M206 environment itself imposes constraints on what may be examined, and so the methods used here might profitably be employed in a different learning context, for example one which has more open-ended tasks or which requires more sophisticated programming activity. AESOP does not support questions beyond the boundaries of the learning environment; however, AESOP could be coupled with in situ observational methods to examine the broader context.

Research Limitations

Although AESOP afforded many opportunities for examination of student behaviour, it also had some limitations, as indicated in the discussions above. There were three major constraints to this research, which excluded questions that might usefully be addressed in future study:

1. Limitations of the data set.

Pragmatics, university rules, and ethics constrained what data could be collected, and to what extent limitations in the data could be rectified through subsequent collection. For example, we could only collect data from volunteers, and the data collection had to be completed during the 2001 intake. An important limitation of the data set, particularly of the detailed recordings of interactions with Learning Books, was that the students were all rather similar in their performance. For example, we have no data from students who failed the course. As a result, questions about the relationship between fine-grained behaviours and performance could not be fully addressed and remain a matter for further study.

2. Limitations of the research context.

This research was anchored in what AESOP could record, and AESOP is embedded in a particular course, M206. Hence, we could only examine behaviours within that context and cohort. The students' activities were constrained by the design of M206, and so we could not address questions about how these students' behaviours might vary given much more open-ended, substantial, or complicated tasks.

However, the research presented has allowed the identification of behaviour patterns such as time-of-day, workspace arrangement and use of notes, which have implications for learning and for course design. The research has further allowed the identification of promising, well-grounded questions for further work, including: "What is the relationship between *Dependent* and *Avoidant* styles and academic performance?" and "What are the characteristics of those programmers affected by a change in programming paradigm?".

3. Limitations to what AESOP captured.

This research demonstrates the effectiveness of AESOP as a research tool to capture and replay a student's online behaviour. Nonetheless, AESOP was not quite as comprehensive a recorder as intended. Some behaviours of interest, such as what notes students make for themselves and to what extent their notes reflect, transform, or extend the learning materials, could not be addressed, because AESOP did not capture fully the contents of the Notes page. The direct relationship between students' behaviour and the part of the practical text being viewed was also not accessible, as AESOP did not record in transcribable detail which parts of the practical text were observable to the student at any moment. This functionality is useful to determine additional details such as whether students respond to instructions immediately or after reading the full text.

AESOP only records events taking place inside the LearningWorks environment. From this viewpoint, other tools which record within the windows environment, such as GRUMPS (*GRUMPS Summer Anthology,* 2001; 'GRUMPS,' 2003) and VibeLog (Hutchings et al., 2004) are worth considering. Depending on their functionality and ability to record within LearningWorks, they could either be used in replacement of AESOP or used in conjunction with it. Recording outside the LearningWorks environment would give greater insight into all the online activities of students.

The recording of other Window events would give additional important insight into what other online tools students are using, such as electronic communications to converse with other students, accessing relevant web based material, making notes, or using alternative, additional CBI material to help with their studies.

Eye-tracking the location and duration of users' gaze (Vertegaal, 1999; Vertegaal and Ding, 2002; Tzanidou, 2003; Vertegaal, 2003) is an additional tool that needs to be considered in combination with AESOP and with other Window logging tools. The data provided by eye-tracking would enable a clearer idea of students' activities to be built up by providing information on how long students spend looking in various windows whether they are reading or even if they looking at the monitor.

Other activities that AESOP did not record were the mouse movements and information on system crashes. By logging mouse activity, it would be possible to determine other behaviours that may not be evident from the current logs. One such behaviour is the use of the mouse as a reading guide noted in basic skills students (Mellar et al., 2005).

M206 reviewed

The behaviours that AESOP can record are constrained by the LearningWorks M206 materials. There are 29 LBs in LearningWorks and an overview of the content of those LBs examined in this work is given in Chapter 2. However, because each LB delivers different proportions of prescriptive and exploratory activities, each LB has different limitations and expectations of students' behaviour.

LB09 - Smalltalk Expressions

LB09 is divided into 21 practicals, each of which is prescriptive, asking students to evaluate set code and observe the resultant behaviours. Students are expected to follow the material as set. The task environment is therefore relatively controlled and limits the potential number of interactions with individual characteristics.

LB10 - References to Objects

The 10 practicals are mainly prescriptive, but later ones require students to revise earlier simple code by using it for example to create new instances of an object. Students are expected to behave the same as in LB09, but it is possible that students would revisit earlier LBs for information if they were unable to remember. This behaviour would show up as the LB being closed then reopened later, as only one LB can be opened at a time. A possible alternative behaviour would be the observation of a student accessing some online notes, either the *Notes* page or an external program.

LB12 - Discussing Software

Students are prescriptively guided through the process of creating three new classes and sending various messages to them. In the final practical (Practical 9), students are asked to make a critical appraisal of the software and post this to the M206 conference. As with LB09, students are likely to follow the material as set.

LB13 - Creating New Behaviours

Students are guided through a series of 10 practicals focussed on creating new behaviours for a class of objects by creating new methods. In the last 2 practicals, students are asked to create 2 methods and are given analogous code as a template, which does not require them to explore prior material, although this is possible.

LB14 - New Behaviours: Answers and Arguments

LB14 is the first LB to ask students to develop their own code to carry out a set function without being guided or given an analogous template from which to work. The change from prescriptive, guided tasks to more open ones presents greater opportunity for individual characteristics to be demonstrated.

LB15 - Subclasses

Similarly to LB14, students are guided at first, and then asked to carry out programming tasks without being given additional help. These latter tasks offer greater opportunity for individual characteristics, such as those reliant on students' organisation and understanding, to be expressed. Students may also be seen to refer back to earlier points in the chapter as the tasks involve ideas introduced within this chapter.

LB20 - Collaborating and Orchestrating Objects

All the practicals in LB20 require students to create their own code to solve problems, and these open tasks offer greater opportunity for individual characteristics, such as those reliant on students' organisation and understanding, to be expressed.

M206 General Limitations

Although LearningWorks material includes tasks that require students to be more exploratory, these tasks are still constrained. One constraint is the nature of these tasks, asking students to arrive at a specified solution/goal rather than being exploratory and requiring students to develop their own goals. Another constraint that becomes increasingly evident as the LBs progress is the availability of tools within the learning environment. This extends to the number and levels of class and methods students have available to them.

The mixture of tasks within LBs suggests the need to look at individual practicals rather than whole LBs. This had not been taken into account when the analyser was designed.

In this work, LBs were chosen for their task content and analysed independently, but how individual students progress through all the LBs has not been explored. Ideally such longitudinal studies should be at the level of detail of individual practicals rather than whole LBs and would give an insight into how behaviours change over the course of study. This is particularly relevant, in the context of the finding that learning styles vary over the course.

Implications for future work

Proposal for a richer Recording and Analysis tool

AESOP is a powerful recording tool, but it has limitations. In this work, ways to overcome these limitations have been suggested, leading the way to the proposed design of a multilevel research tool.

The proposed research tool, incorporates logging of any Microsoft Windows© and LearningWorks events. An additional level of functionality would be the ability to provide eye-tracking information. However, this raises issues about students' privacy (Cooper, 1998; Martin Jr et al., 2001; The Stanford Student Computer and Network Privacy Project, 2002). To meet these needs, the recording tool would need to remain unobtrusive but give students the flexibility to disable those components they wished. For example, students might permit logging within the learning environment, but disable recording of other windows events and eye-tracking. Students would also need to be able to choose the level of recording, such as any time the computer is switched on or just those times LearningWorks is used. The functionality of being able to temporarily switch off logging in similarity to the Google Desktop Search tool (2005) should also be considered.

The Replayer should be able to replay all recorded events at the same time, so that the observer has a clearer picture of the event sequence. Eye-tracking information, if present, should be available as an overlay on the Replayer, showing the location of the student's gaze at any point in time. Events should be replayed so that resolution of the student's screen is put into context. A suggested way of doing this would be to replay the recording in a window where the replayed image is proportional to the one recorded.

Additional functionality would include the ability to mark up recordings for export to qualitative analysis software such as QSR NVivo (*QSR*, 2005), or for qualitative analytic routines to be built in. This could be achieved through the ability to identify and tag or bookmark specific events during replay, together with the ability to search the recording and tag found search terms. This functionality would allow the time taken between any sequence of events to be analysed and the relationship between tagged events or sequences of events to be viewed and analysed in context.

Level of detail

One major outcome of this work is the lack of findings when examining whole LBs. This suggests that future work should be more focussed looking at specific components within one LB, rather than the whole LB.

All the students in the work had passed their exams and for a more complete comparison to made, a detailed analysis of the individual behaviours of students over a range of academic ability is required. In addition to looking at individual practicals, this should be done following the progression of students over the duration of the course.

Measures

In collaborative work with Thomas and Paine (Thomas and Paine, 2000b) it was found that students can have extensive periods of time when there is no observable online activity. This suggests that future work should be looking at the actual time that students take to complete the measured task. The identification and use in this work of the measures *Total Active Time* and *Reading Time Ratio*, which corroborates the work of Hutchings et al. (2004), shows it is possible to have a more accurate measure of the time students spend on the task and provide one possible way for future studies to obtain it.

Future work

There are a number of areas for future work that have been identified in the previous chapters. These include improved questions, suggestions for studies to address these questions, proposals for better methods of assessment, and the development of a multilayered research tool.

Development of AESOP

The conclusion following a critique of AESOP identified the need to address AESOP's limitations. From this came the outline of a multilevel recording and replay tool that would include the potential for eye-tracking information and the recording of other window events outside the LearningWorks system.

These improvements to AESOP would enable additional questions to be addressed such as:

- *Do students use other programs at the same time as studying M206?*
- *What other tools or programs do students use and how do students use them?*

and, in general :

- *Do students who fail the M206 course exhibit different behaviours from those who pass?*

Chapter 3 - Students study behaviours in relation to time

In Chapter 3, the areas for future work that were identified were:-

- To look in more detail at the times when distance education students study, and the relationship between the times students are seen to work and their lifestyles, as well as what constraints they are under.
- Research into whether other distance education courses demonstrate a relationship between the time of day students study and academic performance. For example, would a course that is more factual and has greater reliance on long-term memory show some correlation between time of day and academic performance?
- A minor but pragmatic point is to consider ways of improving the accuracy of recordings by monitoring the precision of the system clocks on participants' machines. An estimation of the margin of error to be expected for any future studies reliant on system time could also be obtained from a general survey of the accuracy of system clocks.

Chapter 4 - Relationship between students level of comfort and performance

At the end of the course, a number of students expressed a lower level of comfort for programming than at the start. The majority of these were students who had prior programming experience. This raised the question:

- *What effect does changing the programming paradigm have on students who have previously learnt to program in a different language? And how long lasting is the loss of confidence?*

Further work suggested was:

- To monitor the change in students' comfort over different programming courses and to determine how this relates to students' prior programming experience.

Chapter 6 - Learning styles normative data for distance education students

Distance education students across the range of faculties taking a second level course were found to have a different range of learning styles to the normal population. This raises the question:

- *Do distance education students naturally have a different range of learning style preferences or have their preferences developed while studying?*

Further work suggested was:

- A longitudinal study comparing the learning style preferences of students taking their first distance education course in computing and other distance education students over the duration of their study.

Chapter 9 - Relationship between time taken by students to complete a LB and students' individual characteristics

Students' preferences for the *Theorist*, *Collaborative* and *Visual* learning styles were found to have significant correlations with the time taken to complete some LBs. This suggests the following further work:

- To identify the nature of this relationship and the need to look at LBs in finer detail.
- To follow up the suggestion that students noted to fall behind the course calendar when starting LB09 appeared to do worse in exams than other distance education students. Would this be an early marker to identify students having problems?

Students with a strong *Activist* or *Dependent* style were noted to have significantly greater difficulty with the examinations. This suggests the following further work:

- To explore whether these results are generalisable to rest of the M206 population and to other courses.

- To explore the nature of the relationship and whether students identified early on with a preference for these styles can be given targeted help.

- To explore whether other individual characteristics are related to academic performance in other courses (Chapter 13).

- To identify the characteristics of students needing the most help (Chapter 13).

Chapter 10 - The relationship between the time that students spent reading and individual characteristics

There were no consistent differences found between individuals relating to *Visual* or *Verbal* preferences in behaviour. Further work that is suggested includes:

- Research to look at the relationship between students who are more *Visual* and the use of the *Class Browser.*

- Research into whether students who are more *Visual* benefit from having the information in the *Class Browser* presented to them in a different way such as Visual Mind™ (*Mind Technologies AS,* 2005).

- What is the relationship between students' *Visual* and *Verbal* preferences and the speed with which they read different types of diagrams included within the text, for example, illustrative text versus simple or complex graphs.

Chapter 11

Three studies were discussed, each raising its own set of questions and avenues of future research.

Students' arrangement of online workspace

Students were noted to arrange their workspace early on and repeat the same workspace arrangement in subsequent uses of the same LB. This suggests that students at some point develop a regular way of organising their workspace. Further work suggested to look at this is:

- A longitudinal study, examining how students' arrangements their workspace changes as they progress through the LBs.

The work also raised questions such as:

- *What factors influence how students arrange their workspace? Does increasing the number of tools and possible windows confuse students?*
- *Why do some students prefer to have different windows open and stacked rather than use the tabs within a single window?*
- *Is there a relationship between working memory and whether students use tiled or stacked arrangements of their workspace? Does this relationship affect performance?*

Students' use of additional materials

Some students were found to use the notes page, but its use by individual students was not consistent across a number of LBs. Further studies suggested include:

- Detailed examination into why students do or do not use the additional resources made available to them. *Are there any individual characteristics that identify why these students use the resources? What is the relationship between students' use of additional resources and the task they have been set?*

- Examination of other courses for similar use of additional/supplemental materials. *Do students in these courses use them for the same reason?*

An aspect related to this was identified in the Discussions (Chapter 13)

- Further work looking into students' use of the graphical *World* page in LearningWorks and the relationship of this with students' individual characteristics.

Sequence in which students use materials

The small sample of students observed all followed the course in the sequence it was set. The questions this raises include.

- *What proportion of the student population does not follow course structure? Why do these students not follow the course structure?*

- *When do students develop the habit of following the course structure?*

- *Do any students break from the set course structure in later courses and why? And how?*

- *Are there any courses where students are more likely to not to follow a set course structure? What characterises these courses?*

- *Would students be less likely to follow the online course material in sequence if a different mechanism for accessing the pages was presented to them, such as an always visible Windows Explorer-type folder view? Would students take different, less linear, routes if the linearity of the M206 course presentation was changed?*

- *Is there a relationship between being an active or passive learner and the sequence in which the course is approached?*

- *Do the students who sent in recordings have more time generally and therefore are not under pressure to jump the course structure?*

- *What are the proportions of active and passive learners taking a distance education course for the first time? Does this differ from students choosing to enrol in more traditionally taught classroom settings?*

Chapter 12 - Comparison of pre- and post-study learning style preferences

Students who completed both sets of questionnaires were found to have significantly greater preference for being *Visual* and significantly less preference for being *Dependent* than students who had only completed the pre-study questionnaires. A further study that follows on from this would be:

- A detailed comparison of a group who volunteer for a survey with a group not given the choice.

The Computing General Demographic Questionnaire

In the Discussion, areas of the Computing General Demographic Questionnaire that require further work include:

- Development of the questions and scale used to measure students' level of comfort.

- Development of questions relating to students' prior experience of programming.

- Validity and reliability studies on the Computing General Demographic Questionnaire.

- Development of the online HTML form to avoid accidental or multiple submissions of the questionnaire.

Other areas for future study.

Online Behaviours

One line of enquiry not researched in this work examines the different ways that students approach error messages generated after an expression was evaluated. In the replay of participants' recordings it was noticed that the way participants dealt with error messages tended to fall into three categories. After dismissing the error message participants would either:

- ignore the error and continue working, carrying on to the next task,
- keep trying to resolve the error until a solution had been achieved, or
- keep trying to resolve the error for a number of trials or length of time before carrying on to the next task.

Those that kept trying to resolve an error until a solution was achieved, were notable for the number of attempts they made to achieve this. One area of future research is to look in detail at these three different behaviours, with the objectives 1) to determine whether individual students behave in the same way on different occasions and 2) to look at the task and type of errors involved, and whether these change the way students respond to errors. A conjecture is that some students have mentally allocated a certain amount of time to resolve an error, so some students will stop at this point while others carry on to resolve the error.

The way in which students deal with errors is also relevant to studies looking at individuals' cognitive and learning styles, as the method used by the student to solve an unexpected problem (the error) gives a direct insight into the underlying cognitive processes taking place. Even if a student just immediately dismisses an error message and continues, this provides information about the way the student approaches problems.

A potential addition to the design of future work looking at errors is the addition of the 'Coach' (Chapter 2), a tool that was developed from observations with AESOP, as an additional teaching aid to help students solve their errors. As the Coach is itself a LearningBook, it is possible for the AESOP Recorder to record events that take place inside the Coach as well as other LBs. This would therefore make it possible to determine in more detail the methods students use to resolve an error.

Individual Characteristics.

In the present work, several individual characteristics that were not looked at but considered to be of interest for future study include working memory (Reason, 1984; Baddeley, 1987; 1992) and spatial ability (Kozhevnikov et al., 2002). Students' working memory capacity and spatial skills both have the potential to be related to the way students arrange and use windows. As already discussed in Chapter 11, the relationship between individuals working memory and the way they use windows also has the potential to influence performance.

Another learning style, currently of interest to other researchers (Liu and Reed, 1994; Hall, 2000; Chen and Macredie, 2002; Parkinson and Redmond, 2002; Redmond et al., 2003) that was not included in this research, but should be considered in future work with object-oriented language programming, is Witkin et al.'s 'Field Independent / Dependent style' (Witkin et al., 1977). This style defines how well an individual is able to perceive part of a field discretely from the whole field. It is of interest because those who are Field Independent, as well as being more analytic, may be better at object oriented language programming than Field Dependent individuals, because they should be able to perceive the individual components of the program better than those who are Field Dependent.

General Conclusion

The present work used AESOP, an asynchronous, remote, recording and replay tool, to look at a number of characteristics of student behaviour when studying an introductory computing course, M206. AESOP as a tool, was found to be effective in the collection of detailed data for fine grained analyses to be carried out. A suggestion for an improved multilayered version is proposed to address issues highlighted by the work that AESOP had not been designed to record.

It was found that students' levels of comfort were significantly correlated to examination marks and could be a possible predictor of performance. The *Dependent* and *Activitist* styles were also found to have significant, but negative, correlations with exam performance; results that indicate these styles might be used to recognize those who would benefit from material and training, either to improve their examination performance or to tailor the assessment to suit the individual.

Learning styles were also found to have significant correlations with students' online activities, with the *Visual*, *Verbal*, *Collaborative* and *Theorist* styles all found to correlate with the *total active time* students took to complete certain LBs. Indicating that for these LBs the CBI material provided did not serve all students equally well.

This body of work has also looked at time of day at which material was studied, students' workspace arrangement, use of a notes page, and the sequence in which the course material was approached. All studies have identified a number of avenues of future work that should provide valuable information for course designers and those developing CBI software. Considering the potential benefits to students, these findings emphasise the need for research into the relationships between individual characteristics and students' use of CBI material. The benefits to course designers are increased accessibility to the course, improved outcomes and better achievement of course goals.

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Appendix A

AESOP
Computing General Demographic Questionnaire

Thank you for participating in this research project, by completing the following questionnaire and providing a little information about yourself you will be helping build up our knowledge of distance education students and the ways that students learn to program.

If you are using a dial-up connection, you may disconnect your computer from the Internet as soon as this form has loaded. You can then complete the questionnaire at your leisure. Whfen you are ready to send the completed form to the OU, reconnect to the Internet. When connected, click the **Submit** button at the bottom of this page.

All answers will be made anonymous.

Thank you again for your help.

Kit Logan
Research Student
The Open University

k.logan@open.ac.uk

1. **Name**
2. **Username** **(e.g. abc12)**
3. **E-mail Address**
4. **Gender**
   - Male
   - Female
5. **Age**

Under 21	*21-25*	*26-30*	*31-35*	*36-40*	*41-45*	*46-50*	*51-55*	*56-60*	*61-65*	*Over 65*
○	○	○	○	○	○	○	○	○	○	○

6. **Current occupation**
7. **Postcode**
8. **How often do you use a computer in your current job?**

   <please select>

9. **How often have used a computer in any capacity?**

   <please select>

10. **If you use a computer on a weekly basis or more often, please estimate the number of hours per week you spend on the following computer based activities:**

    a) Work related

b) Study related

c) Playing games

d) Home affairs (finance, record keeping etc.)

e) Communication (e-mail etc.)

f) Accessing the internet

11 How comfortable are you with:

a) Using different kinds of computing applications? Please Select...

b) Using programming languages? Please Select...

c) Using the internet? Please Select...

d) Using electronic conferencing or e-mail? Please Select...

e) the process of software installation? Please Select...

12 Have you had any previous programming experience?

Yes

No

If Yes, please detail your experience in the box below.

13 Have you studied any other Open University courses before M206?

Yes

No

If Yes, please detail your experience in the box below.

14 Have you studied any other courses that are computing related?

Yes

No

If Yes, please detail your experience in the box below.

15 **Because the way we use computers is greatly influenced by the computer itself, we would be very grateful for the following information about your computer system (if known).**

The main processor	Please Select...
If 'Other...' please state	
The processor clock speed (MHz) e.g. 233	Please Select...
If 'Other...' please state	
The amount of system memory / RAM (in MB)	Please Select...
If 'Other...' please state	
Monitor or screen size	Please Select...
If 'Other...' please state	
Screen resolution (if you don't know the answer, click on Start>Settings>Control panel>Display>Settings tab)	Please Select...
If 'Other...' please state	
Operating system.	Please Select...
If 'Other...' please state	

Thankyou for taking the time to assist us in our research.

Please press the SUBMIT button to send us your answers.

Submit Clear

Appendix B

AESOP Post Project Questionnaire

May we take this opportunity to thank you for participating in this research project. Your help is enabling us to carry out some very interesting research. It is hoped that AESOP can be used as a teaching tool for the M206 course in the future, and as a research tool to provide an insight into the ways that students learn to program.

We would appreciate any feedback on this year's project. We would be very grateful if you would take a few minutes to answer the questions below, and press the SUBMIT button when you are finished.

If you are using a dial-up connection, you may disconnect your computer from the Internet as soon as this form has loaded. You can then complete the questionnaire at your leisure. When you are ready to send the completed form to the OU, reconnect to the Internet. When connected, click the **Submit** button at the bottom of this page.

1. **Name***
2. **Username*** (e.g. abc12)
3. **E-mail Address**
4. **Occupation:**
5. **Postcode:**
6. **If you volunteered to take part in the AESOP project but did not send recordings, for whatever reason, it would be useful for us to ascertain the reason why and we would be very grateful if you could tell us so that we can improve things for future students.**

   You may tick more than one reason.

   - Problems with the AESOP Software
   - Problems with M206 Software
   - Time constraints
   - Personal reasons
   - Other

   Please state any details in the box below

7. **Did you receive notification of the need to reinstall the AESOP software after installing the second M206 CD later on in the course?**

   - Yes
   - No

8. **If you started to send us recordings, but discontinued, it would be useful for us to ascertain the reason why so that we can improve things for future students.**

You may tick more than one reason.

- Did not receive notification for reinstallation of AESOP software
- Did not have access to AESOP software
- AESOP software reinstallation problems
- Time constraints
- Personal reasons
- Other

Please state any details in the box below

9. **How often do you use a computer in your current job?**

- Regularly on a daily basis
- Regularly on a weekly basis
- Regularly on a monthly basis
- Occassionally
- Never

10. **If you use a computer on a weekly basis or more, please estimate the number of hours per week you spend on the following computer based activities:**

work related

playing games

home (finance, record keeping etc.)

communication (e-mail etc.)

using the internet

11. **How comfortable are you with:**

Using different kinds of computing applications?

Using programming languages?

Using the internet?

Using electronic conferencing or e-mail?

The process of software installation?

12. **It would be useful to know why you decided to take part in this project.**

You may tick more than one reason.

- For the benefit of future students studying the course

- [ ] Interest in research
- [ ] Interest in the Open University
- [ ] Benefits to my study
- [ ] Other,

Please state any details in the box below

13. Do you feel that participating in this project has taken up much of your time?

14. Do you feel that participating in this project interfered with your study?

15. Have you experienced any problems with the software needed for this project in:

a) Locating / Obtaining the software

- ( ) Yes
- ( ) No

If Yes, please explain in the box below

b) Installing the software?

- ( ) Yes
- ( ) No

If Yes, please explain in the box below

c) Using the software?

- ( ) Yes
- ( ) No

If Yes, please explain in the box below

d) Any other problems?

- ( ) Yes
- ( ) No

If Yes, please explain in the box below

16. Were you able to contact any of the staff of this research project if needed?

- ( ) Yes
- ( ) No
- (•) Did not need to

17. Please tick which method of communication you found or would find the most effective in contacting us:

- [ ] Telephone
- [ ] E-mail
- [ ] FirstClass Conference
- [ ] Other, please state:

18. Would you like to receive any feedback from the project? (other than looking at our website)

- ( ) Yes
- ( ) No

If Yes, please state the kind of feedback that would be of interest to you in the box below:

19 How much do you know about the AESOP project you are taking part in?

- (•) Did not understand the project
- ( ) I know a bit about the AESOP project.
- ( ) I know what the main aims and objectives of the AESOP project are.
- ( ) I know what aims and objective of the AESOP project are and how my

contributions have helped towards these.

20. Do you think that you have gained anything from participating in this project?

- Yes
- No

If Yes, please explain in the box below:

21. Has your experience in this project made you likely to participate in any other research projects?

- Yes
- No
- Unsure

If Yes, please explain in the box below:

22. We would welcome any other comments or suggestions you may have for next years project, please use the box below:

Thankyou for taking the time to assist us in our research.
If you have disconnected from the Internet, please remember to reconnect before clicking on Submit.

Please press the SUBMIT button to send us your answers.

Submit   Clear form

Appendix C

Personal Communications

From: Tony Grasha
Date: 14 September 2001 12:29
To: Kit Logan
Subject: Re: Help # 1 o2

========

Kit:

The values you gave me are from the scoring key for the instrument. The high, low, and medium values in that self-scoring key were relatively high, med, low values that I set up based upon the standard deviations for the norms that I had. Low values were about 1 Sd below the mean, and high values began about 1SD a above the mean with medium values + or - 1SD above and below the mean. The goal was to get scores that put approximately 20-25 percent- of the sample approximately 1SD below and 20-25%- approximately 1SD above the mean.

The original data from which the self-scoring key was established is buried in archives and I just don't have the time to go back and retrieve it and figure out exactly what the cutoff points were since they varied somewhat for each scale. Its been more than six years since that table was constructed. But the general heuristic for doing so is provided above. I did not use normalized scores or percentiles to set it up.

I generally think it is better to establish relatively high, md, and low scores for specific samples since the samples are not equivalent particularly those across cultures. Too many things vary and thus direct comparisons would need to be taken with a grain of salt.

I wish I could be more helpful with this but I'm just too tied up with newsmedia related to the terrorists attacks and other non-learning style and high priority projects to be of much more help at the moment. To give you more about the model in which all of this falls, I've attached in pdf format (go to www.adobe.com) to get a copy of Acrobat reader as a free download if you do not already have one (version 4.0 or higher). Also if you are a PC user, be sure to save the file with another name and attach .pdf to the file name.

I do have the SD for the teaching style part of the model listed below if that should be of some interest to you.

Also in a second email, I've attached additional information on where the work comes from.

Listed below is the standard deviation data for each of the faculty groups on the teaching styles inventory.

Discipline: Exp FAU PM Fac Del
Arts/Music .71 .46 .56 .94 .73
Humanities 1.19 .78 .72 1.05 1.02
Languages .77 .63 .64 .84 .69
Social Science .95 .86 .73 1.11 .86
Applied Studies .93 .80 .67 1.12 .94
Applied Science .96 .87 .79 1.08 1.01
Business Adm 1.19 .83 .95 1.21 1.23
Phy/Bio Science 1.00 .76 .90 1.09 .94
Math/Computer .86 .74 .59 1.00 .71
Education .88 .79 .81 .99 .87

From: "Brown, Alan" <abrown@mail.smu.edu>
To: "Kit Logan" <k.logan@open.ac.uk>
Subject: RE: Visual Verbal Questionnaire
Date: 19 June 2003 14:51

I spent several years (with at least 3 graduate students) trying to develop expanded versions of the questionnaire for both children and adults. Each of these efforts ground to a halt, mainly because a) we could not get a version which had three factors fall out cleanly (vis, aud, kin), and b) there were some problems with reliability on repeated administrations.

In each try, we came to the conclusion that there are too many academic expectations contaminating the process. That is, students think that there are certain ways to answer the items which fit with a studious mold (mainly visual plus auditory). I think that the only way to refine such a questionnaire successfully is to through a broad, community based sample including a variety of different (non-student) individuals.

AB

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-----Original Message-----

From: Kit Logan [mailto:k.logan@open.ac.uk]
Sent: Thursday, June 19, 2003 7:23 AM
To: Brown, Alan
Subject: Visual Verbal Questionnaire

Many thanks for sending me a copy of the questionnaire. I have a few questions about it now that I've had a chance to look at it.

I was intrigued to see you used as well as visual and verbal modes a kinetic mode but looking at the questions I also get the feeling that the kinetic construct as used in the questionnaire is or can be confused with spatial preference. Has any validity studies or factorial studies been carried out on the questionnaire?

My interest in your questionnaire follows its use to evaluate a visual verbal questionnaire developed by Antonietti and Giorgetti (1993). Their questionnaire was written in Italian and I'm currently in the process of evaluating an anglicised version.

Thanks again for the copy.

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From: "Richard Felder" <rmfelder@mindspring.com>
To: "Kit Logan" <k.logan@open.ac.uk>
Subject: Re: ILS validity updates?
Date: 27 January 2003 03:39

Dear Mr. Logan,

A fairly extensive validation study of the ILS is currently being conducted on four campuses, but it will probably be several months before results are forthcoming. I can tell you that the Cronbach alpha (a measure of internal consistency reliability) for the visual/verbal scale has been determined in separate studies to be 0.60, 0.56, 0.69, and 0.63, all above the minimum level of 0.5 recommended for attitude tests by Tuckman (Conducting Educational Research, 1999). Also, Pearson correlation coefficients relating visual/verbal scores with scores on the other three dimensions have all been on the order of 0.05, showing that the visual/verbal scale is independent of the other three.

I would be very interested in the results of your comparison if you decide to carry it out.

Richard Felder

==

----- Original Message -----

From: Kit Logan
To: rmfelder
Sent: Thursday, January 23, 2003 10:20 AM
Subject: ILS validity updates?

I am interested in finding out if the updated second version of the ILS questionnaire has been validated yet. You mentioned several studies were underway, but no results yet. Unfortunately the web page does not have a date on it so I have no idea of the current accuracy of this information.

My reason for asking is that I would like to compare another visual verbal strategies questionnaire with the visual verbal content of the ILS, but this would be of no use if there are no validity studies for the ILS.

Many thanks
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